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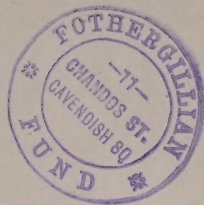
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TO
GEORGE MURRAY HUMPHRY,

M.D., F.R.C.S., F.R.S.,

HON. FELLOW OF DOWNING COLLEGE, FELLOW OF KING'S COLLEGE, CAMBRIDGE;

PROFESSOR OF SURGERY IN THE UNIVERSITY OF CAMBRIDGE; AND PRESIDENT OF THE ANATOMICAL

SOCIETY OF GREAT BRITAIN:

WHOSE TEACHING HAS DONE SO MUCH TO ADVANCE

THE STUDY OF

Philosophical Anatomy

IN GREAT BRITAIN,

This Work is Dedicated

AS A MARK OF RESPECT AND ESTEEM

BY

THE AUTHOR.

P R E F A C E.

THE Anatomy of Man is an ancient and royal subject of study. The first book whereof we have any record was on this theme, and its author was a king. During the succeeding sixty centuries many excellent books have been written on the subject, but most of them have treated of it from the purely descriptive side. It is, therefore, little wonder that traces of traditionalism should survive, and that there should be some basis for the reproach, which has been cast upon Anatomists, that they have been unduly slow to appreciate the light shed on human organisation by the younger allied sciences of Morphology and Physiology.

The facts of Human Anatomy can only become intelligible when Man is considered as a member of the great animal series, and hence the necessity, now generally recognised, of giving to the medical student a preliminary course in Elementary Biology before he begins the dissection of the human body.

In the following pages I have endeavoured to give a comprehensive account of the Anatomy of Man, studied from the Morphological standpoint. The order I have adopted is the outcome of considerable experience as a teacher, and is that which I have followed during the past fifteen years. I have first given a brief sketch of the evolution of form; then a very short account of the nature and arrangements of the tissues. This part I have necessarily made brief, as Histology can only be adequately studied in the Laboratory, and with a handbook treating of methods as well as results. I have then taken up the Anatomy of the bones and joints, and lastly of the soft parts, in the order in which they are dissected by the student. To have followed the order of Systems would have been much easier, but it

is not in this order that the student learns Anatomy in the only place wherein it can be learned, namely, the dissecting-room. For the sake of any who may wish to study a particular System by itself, I have prefixed a Classified Table of Contents, which will enable him to select the proper paragraphs with no greater trouble than that of turning over a few pages.

To study Anatomy with the least labour and the greatest profit, the student should read the complete description of each structure, with the parts before him, checking and verifying every statement as it occurs. By this method far more satisfactory results will be attained than by the plan of using only a short set of descriptions in the dissecting-room, supplemented by the reading-up of the details at home out of reach of the means of verification. By adopting the course here pursued, one text-book should suffice, in place of the customary two. The method is of the greater value, in that the student is not called upon to accept, on the word of the teacher, statements in the verification of which it is, for his own sake, of great importance that he should exercise his eyes and his fingers.

In a subject containing such a prodigious mass of detail, it is impossible within the compass of a Student's Text-Book to present more than a selection of the facts of Anatomy. I have tried to make a selection, including all that is of real importance, with due reference to the bearing of these facts on the allied subjects of Medicine and Surgery, of Morphology and Physiology, and I have endeavoured as much as possible to avoid repetition.

The normal Anatomy of Man is a study of averages, and it is often hard to draw the line between what may be regarded as normal and that which is abnormal. I have endeavoured in each case to decide in accordance with what I have seen and noted during the past thirty years of my dissecting-room experience. I have, moreover, left out the names of those authorities whose work has advanced our knowledge in each department; such names are useless to the ordinary student.

When a discovery is once sufficiently verified, it becomes a part of the science, and is the property of all. The record of the discovery is a part of the history of the science, not of the science itself.

I hope at some future time to set forth in order what I have here been obliged to omit, a complete catalogue of recorded varieties and their statistics, and a detailed history of the progress of Anatomical discovery.

To study profitably, the student must dissect carefully; one part dissected with care is worth a dozen hurried over. In these days of antiseptics there is no difficulty in keeping parts for careful work, and now every dissecting-room is provided with some such preserving fluid. What I have found most suitable is a mixture containing spirit 30 per cent., glycerin 10 per cent., carbolic acid 2 per cent., and water 58 per cent. When a subject is properly injected with a preservative, such as arsenic and glycerin, or an alcoholic solution of mercuric chloride, cloths wet with this fluid wrapped round a part will suffice to preserve it indefinitely.

There is little scope for originality in the writing of a Student's Text-Book; every structure has been so often and so well described before, that I cannot expect to do better than my predecessors. The descriptions given here have been written in the dissecting-room, and checked over and over again by comparison with dissections.

I have to record my indebtedness to many kind friends for helpful suggestions. I have especially to thank Dr. Hill, the Master of Downing College, for his kindness in reading much of the work in manuscript, especially the account of the central nervous system. I have also to thank Professor Curnow, Dr. Donald MacAlister, Mr. Rolleston, and Mr. Grünbaum, for having read through most of the proofs, and for many hints and criticisms, of which I have gladly availed myself. I am also indebted to the publishers for their kindly forbearance with my tardiness, and for the liberality with which they have provided the numerous illustrations. Very many of the latter have been

engraved expressly for the work; for others I am indebted to Landois and Stirling's *Text-book of Physiology* and Haddon's *Introduction to the Study of Embryology*. The sources of the remainder are given elsewhere.

I have freely availed myself of the results of the researches of the many great masters who have done so much to develop the morphological side of Human Anatomy, and am especially indebted to the suggestive writings of Gegenbaur, His, and Krause, as well as to those of Gaskell, Cunningham, Lockwood, and Sutton. I have lastly to thank my friend and successor in Dublin University, Professor Cunningham, for the opportunities which he has afforded me of examining and using many of his beautiful preparations, especially those dealing with cranio-cerebral topography.

ALEXANDER MACALISTER.

TORRISDALE,
CAMBRIDGE, November, 1889.

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CORRIGENDA.

Page 85, fig., *for* "arteriousus," *read* "arteriosus."

„ 309, fig., delete *a* before adductor and abductors.

„ 349, line 36, *for* "left," *read* "right."

„ 349, line 37, *for* "right," *read* "left."

„ 430, fig., *for* "iliocolic," *read* "ileocolic."

„ 486, fig., *for* "aod," *read* "adductor."

„ 612, line 26, *for* "next," *read* "last."

„ 619, line 2, *for* "styloglossus," *read* "stylopharyngeus."



INTRODUCTORY.

1. The Anatomy of Man may be studied from two different stand-points, the morphological and the utilitarian. To the student of Morphology, Man is the best-known and the most easily examined of the higher Mammalia; and the dissection of the human body is more suggestive of important morphological lessons than that of any other single species. The student of Medicine regards the human body as an apparatus liable to disorder and injury, whose mechanism it behoves him to know, in order that he may be able to deal with its diseased conditions.

Although the facts which are of primary importance to each of these classes of students are to some extent dissimilar, yet the Anatomy itself is one; and it is possible so to treat the subject as to set forth for each student that which is necessary for his particular purpose.

An adequate knowledge of the Anatomy of Man can only be obtained by careful dissection. To the practitioner of Medicine such an accurate knowledge is essential as will enable him to place his finger over, or the point of a needle in, any required part; as well as to understand the structure of the part so indicated. Any less precise knowledge is of little value.

Man's body consists of a combination of six **systems** of parts—skeletal, muscular, nervous, digestive, circulatory, and genito-urinary. Each **system** is made up of a set of **organs**; each organ is built up of **tissues**, whose ultimate constituents are called **form-elements**. Anatomy takes account not only of the parts which can be distinguished by the naked eye, and which are studied by dissection, but also of those minuter elements which require the aid of the microscope and of reagents for their recognition. The former side of the science is **Macroscopic**, the latter is **Microscopic Anatomy**; but between these there is no hard line of demarcation. The study of the tissues and form-elements is called **Histology**.

Method.—In some treatises the systems are described separately in sequence; in others, the parts of all systems are studied in the order in which they are met with in the dissection of the body. The former method of treatment is *Systematic*, the latter *Topographical*. The skeletal, digestive, and genito-urinary systems are more easily studied by the examination of their component organs systematically; but, owing to the inter-dependence of the parts of the muscular, circulatory, and nervous systems, especially in the head, neck, and limbs, it is more useful to adopt the topographical method in the description of these regions.

Terminology.—The names given to the parts of the body are singularly heterogeneous. In the literature of Anatomy over 14,800 names have been applied to about 7,200 parts. I have selected the names in most general use, choosing, when possible, such as are single words, if neither too long nor cacophonous; considerations of priority, precision, and appropriateness being, where possible, respected. Many names are so linked with the history of the science that they should not be altered, and however desirable a consistent nomenclature may be in theory, recent attempts in that direction have been singularly unfortunate.

Opinions differ as to the propriety of retaining the personal element in anatomical nomenclature. I have retained such names wherever they constitute historical memorials of discovery; and while their undue multiplication is to be deprecated, yet it would be a pity to divorce the names of Morgagni, Spigelius, Vieussens, Wharton, Monro, or Colles, from the parts with which their names have been so long associated.

An appropriate terminology, although desirable, is only a means toward an end. In

Anatomy there is greater danger than in any other branch of knowledge of the student falling into the error of confounding *names* and *things*. An acquaintance with the literature of the science is quite compatible with gross practical ignorance of the parts themselves.

Descriptive Terms.—In anatomical description, the body is supposed to stand upright, so that *upwards* and *downwards* mean respectively towards the head and towards the feet. The anterior surface of the body is called **ventral**, the posterior **dorsal**. That aspect of any part nearer to, or directed towards, the head is called **proximal** or **preaxial**, while that more remote or directed from the head is **distal** or **postaxial**. The terms *superficial* and *deep* are applied to parts according as they are respectively nearer to, or farther from, the skin. *Pre-* and *postaxial* indicate aspect rather than position.

A vertical plane of section carried from before backwards is called a **sagittal** section, while a section in the vertical plane at right angles to this is said to be **coronal**. Thus a skull divided vertically from nose to nape, into two lateral portions, is “sagittally” divided; but if cut through vertically from ear to ear, and so divided into fore and hind halves, the section is “coronal.”

The sagittal plane which divides the body into symmetrical lateral halves is the **median plane**, which intersects the surface before and behind in the *anterior* and *posterior median lines*. According to their relation to this plane, parts are divided into **medial** (nearer, or directed towards the median plane), and **lateral** (or farther away on each side of it). Thus, that aspect of a limb which is directed towards the median plane is the “medial aspect,” and the opposite is the “lateral.”

2. SYMMETRY.—The skeletal, muscular, genito-urinary, circulatory, and nervous systems are essentially alike on each side of the median plane. The digestive organs were originally divisible into two laterally similar halves by the median plane, but from inequalities of growth they have lost their primitive symmetry.

As in other vertebrates, traces of the original division into successive segments or *metameres* remain in all systems except the digestive; and in consequence, *serial homologies*—that is, resemblances between comparable parts developed from corresponding portions of successive segments—are recognisable.

3. VARIABILITY.—No two human bodies are exactly alike in the details of organisation. Inheritance, habitual actions, occupation, and other circumstances of environment, are factors which act with unequal intensity in the history of each individual, modifying the proportional development of parts. Although the resulting range of variety is great, yet there are certain conditions of each part which, from their frequency of occurrence, it is convenient to call *normal*, and these only are here described.

The enumeration of the recorded varieties of parts is out of place in a student's handbook, so I have relegated their full tale to a supplemental volume. These anomalies may be grouped in five categories.

1. *Embryonal*, the persistence, in the adult, of conditions usually transient in the fetus.
2. *Atavistic*, the occurrence of conditions which existed in ancestral forms, but which have disappeared even from the human fetus, under the action of environing influences. These two groups are closely related.
3. *Retrogressive*, due to lack of nourishment of parts, causing their atrophy, degeneration, or disappearance; loss of function having preceded degeneration of structure.
4. *Vicarious*, alterations due to the assumption of supplementary functions by certain parts, compensating for the deficiencies of others.
5. *Progressive*, due to increasing function, and foreshadowing increase of specialisation.

4. THE UNIT OF ORGANISATION.—All human tissues consist of, or are derived from, **cells**. A cell in its simplest form is a minute mass of a transparent, gelatinous, contractile material called *protoplasm*, which is insoluble in water, coagulates at 130° F., and is usually neutral in reaction.

Protoplasm is highly metabolic, and easily breaks up into more stable albuminoid substances, which can generally be stained crimson with carmine, and purple with logwood.

These derivatives may appear as granules in the cell-substance, which become ejected in the course of the life of the cell; or they may remain in organic union with the cell as a more or less clear, homogeneous peripheral material, exhibiting none of the living characters of the protoplasm which it surrounds.

When a layer of this *metaplasm* is condensed into an investing layer around a cell, it is called a **cell-wall** (fig. 1, *mc*), and this is usually of sufficient firmness to give to the cell a definite shape, and to restrict or prevent the amoeboid motion which naked masses of protoplasm exhibit. In general, protoplasm forms only a small constituent in any but the youngest cells. The metaplasm which lies external to the limits of the cell, thus defined, often undergoes metamorphosis, and forms an intercellular ground-substance, upon the nature and amount of which the permanent arrangement of the cells in the tissue depends.

The material of the cell is probably never homogeneous, but usually consists of a network of minute, highly refracting, and firmer filaments (fig. 1, *pc*), whose meshes are filled with a more fluid substance (*enchylema*). Scattered through these are granules of metaplasm, food, or of other foreign matter, as well as very fluid drops of low refrangibility, called *vacuoles*, whose presence seems to weaken the contractility of the protoplasm.

Nucleus.—Within almost every cell is a roundish vesicle, called the *nucleus*, which consists of an investing homogeneous *membrane of the nucleus* (fig. 1, *mn*), enclosing a network of protoplasmic threads (*nucleoplasm*, *pn*) similar to the reticulum of the cell, with an *enchylema* of lower refrangibility in its meshes, which is with difficulty stained by reagents (*achromatin*). Embedded in this nucleoplasm there is a convoluted filament of a coloured material (*chromatin*, *bn*), usually moniliform in outline, and exhibiting nodal swellings (*nucleoli*) where two parts cross each other.

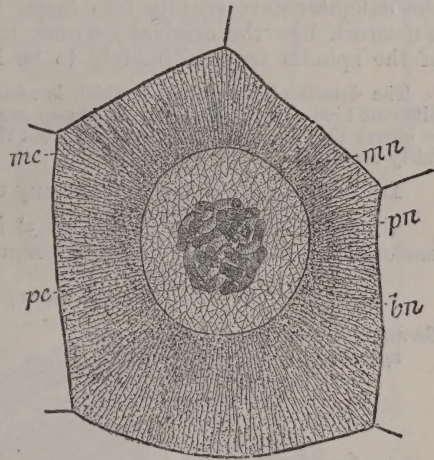


Fig. 1.—Typical nucleated cell.

Cells grow in the direction of least pressure, and vary in shape according to their environments. There seems to be a limit to their indefinite enlargement, and when this is attained, well-nourished cells multiply by division. Human cells are variable in size. Among the largest are the cells of the anterior horn of the spinal cord ($135\mu^*$); among the

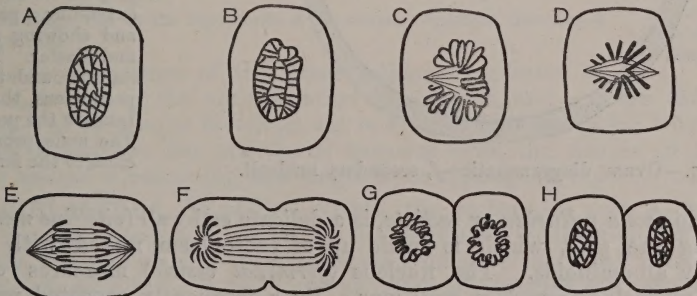


Fig. 2.—Karyokinetic changes in a cell which is about to divide.

smallest, are probably the minute fusiform cells of the retina (10μ). It is probable that the organisation of a cell is even more complex than has been hitherto suspected, as the smallest human cell may consist of over half a million molecules.

* $\mu = 0.001$ of a millimetre.

The Multiplication of Cells is preceded by complex changes, as yet imperfectly understood. In the course of these, the nuclear membrane usually disappears, and the coloured nuclear filament enlarges (fig. 2, **A**) and loosens (**B**), forming a convoluted wreath (**C**), which breaks up into a series of loops (**D**), from which a pencil of rays extends toward each pole of the cell (the monaster stage). The spindle-like figure thus formed consists of fine lines (**E**), and the loops of the chromatin filament around it become divided into two star-like circlets of rays which gradually separate from each other (**E**), the spindle becoming somewhat barrel-shaped (pithode stage). Each circlet of loops becomes united into a new rosette (**F**), the cell appearing as a diaster. In the middle of the spindle, where its rays are interrupted by a layer of granules, an equatorial plane of division appears, and the protoplasm of the cell and nucleus become rapidly aggregated around the daughter-stars. The rays of the daughter-stars reunite into loops, these into wreaths (**G**), and these into a network like the original network in the parent cell (**H**); while the halves of the spindle seem ultimately to be lost.

The details of this process, which is named **Karyokinesis** or **Mitosis**, vary in each different kind of cell. In some the phases are minimised to an almost simple fission, while in others they are much more complex; but the general features of the mode of division are fairly constant.

Individual cells live as long as any of their protoplasm remains unaltered.

5. THE HUMAN OVUM (fig. 3) is a large cell, 0.16 mm. in diameter, enclosed in a firm envelope, 0.01 mm. thick, pierced by close radial pores.

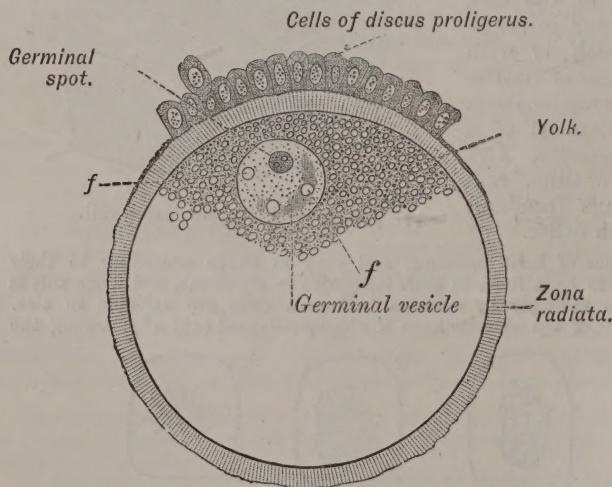


Fig. 3.—Ovum, diagrammatic—*f*, secondary nucleoli.

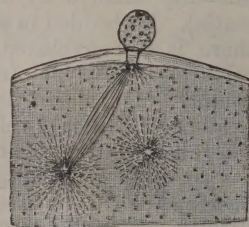


Fig. 4.—Portion of ovum extruding a polar body, and showing a spindle and diaster. The inner stars surround the female pronucleus, the outer is beneath the polar body. The male pronucleus is close to the female.

Within this *zona pellucida* or *radiata*, is a delicate cell-wall (*vitelline membrane*), containing the *yolk*, which is made up of protoplasm mixed with vitellin and other albuminoids. The nucleus (*germinal vesicle*) measures 0.04 mm., and the nucleolus (*germinal spot*) 0.007 . By a frequently repeated process of division, and by the modification of the new cells so produced, this one fundamental cell gives origin to the embryo, and the embryo develops into the adult individual. The study of the specialisation of the products of this cell-multiplication, which is named *Embryology*, is the only reliable guide to the solution of the many morphological problems which Human Anatomy presents.

It is desirable, therefore, to begin the study of Anatomy by a short preliminary survey of the development of the general form of the human organism from the simple egg cell.

Presegmentation Changes.—The later stages of maturation and the beginning of segmentation have not been observed in the human ovum; but as the immature egg and the later stages of development in man closely resemble the corresponding stages of these in other mammals, it is reasonable to suppose that an equal similarity exists in the intermediate conditions.

The cell-contents of the maturing mammalian ovum undergo a series of karyokinetic changes, which end in the disintegration of the germinal vesicle, in the extrusion of small spherules (*polar bodies*, fig. 4), and in the reconstruction, from the material around the remaining star, of a single nucleus for the ripe egg (female pronucleus).

Fertilisation of the ovum takes place by the entry of a single spermatozoon (fig. 5) into the yolk and the fusion of its middle piece (*m*), which becomes the male pronucleus, with the female pronucleus. The new nucleus arising from the fusion of these two, together with the whole yolk around it, immediately begins to undergo change, cleaving into two segments or **blastomeres** (fig. 6, *a*), each of which again subdivides (*b, c, d, e*) repeatedly. The human ovum is *holoblastic*, i.e., the entire substance takes part in this process, which is completed in about four days, the ovum in this stage being called a **morula** (*e*). The segmentation-masses resulting from this repeated division become arranged in two series, an outer layer of somewhat cubical cells derived from one blastomere (fig. 6, *a*, *ect.*) surrounding, except at one spot, the inner mass of roundish cells. These inner cells at first fill up the whole cavity within the outer; but in process of growth the outer lamella or ectoderm (fig. 7, *ect.*) expands more rapidly than the inner cell-mass (fig. 7, *ent.*), which only adheres to one part of the inner surface of the external lamella, while the rest of the space around it becomes filled with fluid. The **blastodermic vesicle** thus formed within the *zona pellucida* (fig. 7, *zp.*) is bounded consequently by a single layer of outer cells, except at one region where the flattened and lenticular inner cell-mass is attached.

In this stage the ovum represents a Mesozoan organism developed around an axis.

The central portion of the inner cell-mass increases in thickness, owing to the multiplication of its cells, and appears through the outer layer as an opaque blotch (at *ent.* in fig. 7). This *embryonic area* is at first roundish in outline, but afterwards becomes oval, the margin of the inner stratum around it remaining as a single layer of irregular cells.

6. DIBLASTULA STAGE.—Within the embryonic area a further re-arrangement of elements takes place a few days after fertilisation. The cells of the inner mass divide into two layers—an inner, of flattened cells, which is called the *hypoblast* (fig. 8, *hy.*); and an outer, of rounded cells, which speedily fuses with the overlying lamella of outer layer cells, forming by this fusion a stratum of columnar cells named the *epiblast* (*ep.*).

The germinal area of the wall of the blastodermic vesicle is now definitely bilaminar, and is distinctly marked out from the zone surrounding it, in which the flattened cells of the outer layer overlie a stratum of irregular cells of the

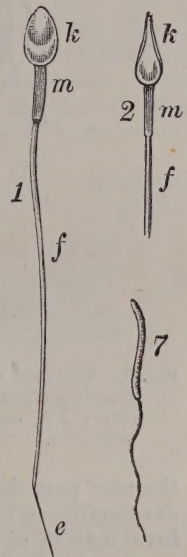


Fig. 5.—Spermatozoa—(1) human, seen from the side; (2) on edge; *k*, head; *f*, tail; *e*, terminal filament; (7) spermatozoon of woodpecker.

primitive inner cell-mass. The rest of the wall of the blastodermic vesicle consists of outer layer cells alone.

In this stage the ovum is comparable with the simplest Metazoa.

7. EARLIEST TRACE OF BILATERAL SYMMETRY.—A few days later (probably about the seventh), an obscure cloudy spot near the middle of

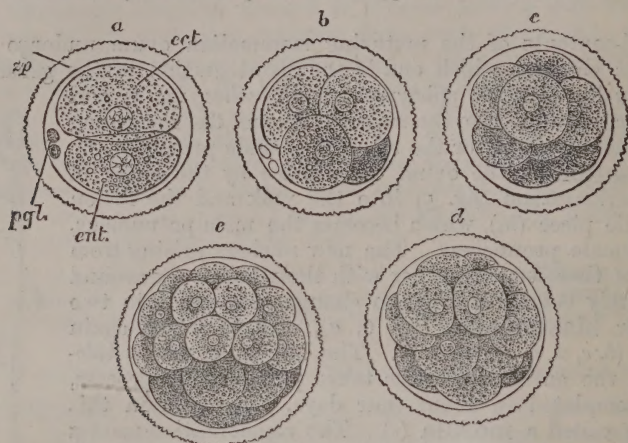


Fig. 6.—Cleavage of yolk—*b*, four-celled stage; *c*, eight-celled stage; *d*, *e*, many blastomeres, showing more rapid division of outer-layer cells, and gradual enclosure of inner-layer cells; *ect.*, outer-layer cells; *ent.*, inner-layer cells; *p.gl.*, polar bodies; *z.p.*, zona pellucida.

the now pear-shaped embryonic area marks the place where, in the more slowly developing embryos of lower forms, the **blastopore** or primitive orifice of invagination of the hypoblast was situated (fig. 9, upper end of *Pr*). This

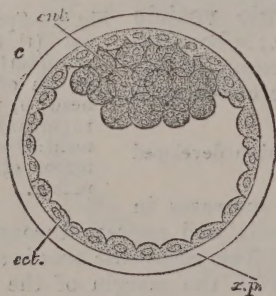


Fig. 7.—Blastodermic vesicle.

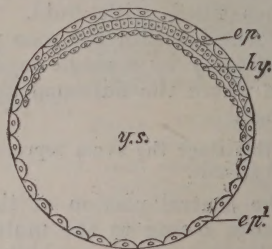


Fig. 8.—Embryonic area of wall of diblastula —*ep.*, epiblast of embryo; *ep.*, epiblast of the area space; *y.s.*, yolk-sac.

indicates that although these stages of development have progressed too quickly to allow the simple gastrula* stage to be isolated, yet that the hypoblast has been produced by invagination. From the blastopore to the posterior edge of the embryonic area, a dark line, the **primitive streak** (*Pr*), extends, and the

* The gastrula stage is that in which the embryo consists of a bilaminar sac opening by a single mouth, the *blastopore*. The two layers of the wall of the sac are epiblast and hypoblast. The gastrula stage of the embryo resembles the permanent condition of some of the lowest Cœlenterate animals.

cells of the epiblast multiply rapidly along this line, forming marginal lips, one on either side of the line. These unite in front and so bound a groove; but they fade off behind towards the edge of the embryonic area.

This streak is historically interesting, being the line of coalescence of the two approximated borders of the embryonic area, caused by the shifting of that area inwards from the edge of the blastoderm where it was originally placed, and where it remains in some more generalised types of animals. Its foremost extremity corresponded to the primitive blastopore, or opening of invagination of the original gastral cavity.

8. FORMATION OF MESOBLAST.—About a day later than the appearance of the primitive groove, two faint ridges called **medullary folds** (*laminae dorsales*) appear in front of the primitive groove, on each side of the middle line. The furrow included between them is called the **medullary groove** (fig. 9, *R.*), and is floored by a streak of epiblast called the **medullary plate**. The medullary folds unite in front of the medullary plate, at the anterior end of the embryonic area and, as in the course of growth they gradually extend backwards, they push the primitive groove to the hinder end of the area, where it finally disappears (fig. 9, *III.*).

Coincidentally with the formation of the primitive groove, an intermediate series of embryonic cells appears between the epiblast and the hypoblast.

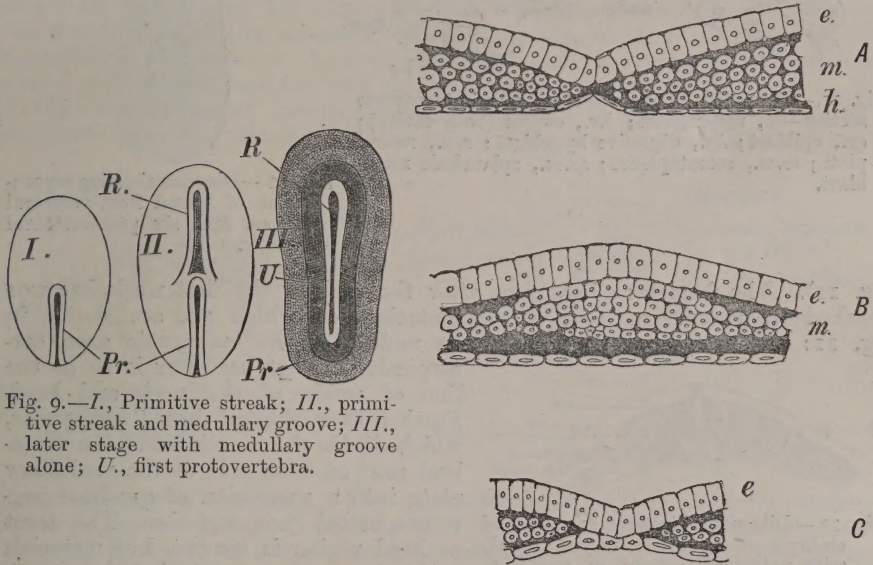


Fig. 9.—*I.*, Primitive streak; *II.*, primitive streak and medullary groove; *III.*, later stage with medullary groove alone; *U.*, first protovertebra.

Fig. 10.—Sections of the embryonic area.

These cells are derived partly from the deeper portion of the epiblast along the whole length of this groove (*mesenchyma*), and partly from the outer surface of the hypoblast in the middle line at the front end of the groove (*mesothelium*). The layer formed by the union of these two sets of cells is the **mesoblast**.

On account of its twofold origin, the mesoblast differs at different points in the median line in its relation to the other layers. The hypoblast is free from the combined epiblast and mesoblast along the primitive streak (fig. 10, *B*), while at its front end where the blastopore was situated (*C*), the hypo- and mesoblast are united, and still farther forward in the region of the medullary groove, the hypo- and epiblast are medially in contact, separating the mesoblast into two lateral plates (*A*). These various relations become intelligible when the formation of the mesoblast is observed in those animals which pass

through these stages more slowly, and in which the mesothelial portion of the mesoblast arises as a lateral pair of outgrowths from the hypoblast close to the orifice of the blastopore. On each side, the mesoblast grows out to the edge of the embryonic area as a distinct layer between the two other primary lamellæ.

9. THE NOTOCHORD AND THE BEGINNING OF METAMERISM.—

Beneath the medullary plate a long rod of cells, derived from a median axial longitudinal fold of hypoblast (fig. 11, *ax.hy.*), separates from the cells on each side (*hy.*). This is the **notochord**, the first trace of the axial skeleton. At this stage, that part of the mesoblast of the embryonic area which lies on each side of the medullary plate (*vertebral zone*, fig. 9, *III.*, *U.*) becomes separated by a clear marginal line from the outer portion of the area which constitutes the *lateral zone* (lighter in colour in the diagram, and in

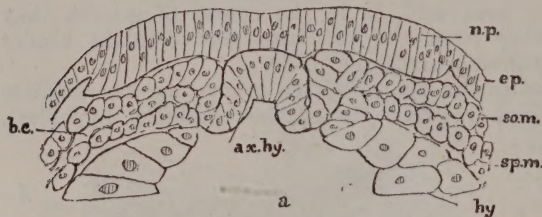


Fig. 11.—Formation of the notochord seen in transverse section—*a.*, mesenteron; *b.c.*, cœlom (body-cavity); *ep.*, epiblast; *hy.*, digestive hypoblast; *n.p.*, neural plate; *so.m.*, somatopleure; *sp.m.*, splanchnic mesoblast.



Fig. 12.—Diagram showing separation of lateral from vertebral zone, and six protovertebral clefts.

fig. 12). The former region, soon after the end of the first week, becomes marked by transverse lines of segmentation, of which six are shown in fig. 12: the first, appearing about the middle of the embryonic area, corresponds to what hereafter is to be the line of union of the neck and head.

Farther back, similar clear lines appear, which divide the mesoblast of the vertebral zone on each side of the medullary plate into a succession of quadrate segments, called *protovertebræ*. The front or head region is composed of materials which in more generalised forms constitute a number of segments, but in the human embryo these do not become



Fig. 13.—Diagram of transverse section of embryo—*n.*, primitive neural canal, with notochord below; *m.*, protovertebra; *s.*, somatopleure; *p.*, splanchnopleure; *c.*, body cavity.

clearly segmented. This region is at first disproportionately long, but its preponderance diminishes as the hinder part of the body elongates.

Formation of the Cœlom.—Outside the vertebral zone the mesoblast of the lateral zone divides into two layers, an outer (fig. 11, *so.m.*) which attaches itself to the epiblast, and forms with it the primitive body wall or **somatopleure**, and an inner (*sp.m.*) which adheres to the hypoblast, and forms with it the **splanchnopleure**, which is to be hereafter the wall of the digestive tube. The space between these layers is the **cœlom** or pleuro-peritoneal cavity (*b.c.*). Processes of this cavity originally extended into the centre of each protovertebra, but these are early shut off from the cœlom (fig. 13, *b*) and

are soon obliterated. The mesoblast by this time has extended beyond the region of the embryo into the portion of the blastoderm immediately around it, and terminates at an equatorial line which can be easily traced.

10. ISOLATION OF THE EMBRYO.—The embryonic area is at first an elongated, slightly raised, opaque region on the surface of the blastodermic

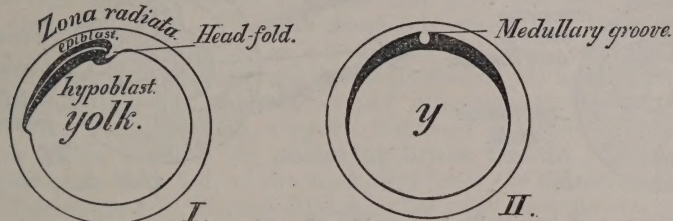


Fig. 14.—Diagram of ovum, showing the isolation of the embryo—I., longitudinal section; II., transverse section.

vesicle. By the end of the first week, it becomes isolated by the development of a clear line around its margin; and a crescentic furrow is produced by the doubling in of the somatopleure, and rapidly deepens in front of the expanding anterior end of the medullary plate, distinctly marking off the head end of the embryo from the rest of the blastoderm in front of it (fig. 14, I., *Head-fold*). A similar groove or *tail-fold* appears at the hinder end of the embryonic area (fig. 15), which is soon joined to the head-fold by a lateral furrow

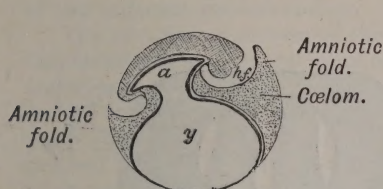


Fig. 15.—Embryo still farther isolated—longitudinal section—*a*, alimentary area; *y*, yolk sac.

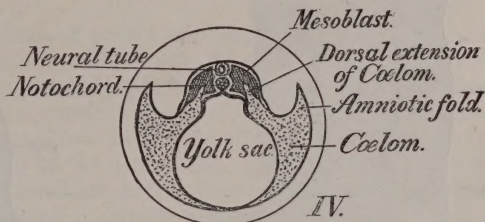


Fig. 16.—Diagram of transverse section of same stage as fig. 15.

along each side of the body. This circumferential tucking in of the somatopleure progresses with such rapidity that by the time the protovertebrae have increased to ten, there is a distinct and continuous furrow around the embryo, which, in consequence, appears joined to the non-embryonic part of the blastoderm by a wide although gradually narrowing pedicle, the somatic stalk (fig. 17). At a later stage, when it has attained to its permanent external form, the embryo is known as the **fœtus**.

While these changes are in progress, the splanchnopleure becomes also folded in, so that the extra-embryonic part of the hypoblast and yolk (the *umbilical vesicle*, *y*) is divided off from the embryonic part which is afterwards to form the digestive canal (*a*). The folding proceeds more rapidly in the splanchnopleure than in the somatopleure, so the splanchnic stalk (*s.s.*) soon becomes a very narrow pedicle.

The Amnion.—Outside the deepening furrow which surrounds the somatic stalk, a lip of somatopleure (figs. 15, 16, 17) rapidly rises like a wall, and converges over the embryo as it rises, ultimately roofing it in, and by

coalescing over it, shutting up the embryo in a closed space. This lip is the **amniotic fold**, and the closed space around the embryo is the **amniotic cavity** (fig. 17), which contains a serous fluid of fetal origin (a transudation from the amnion; at a later stage supplemented by fetal urine).

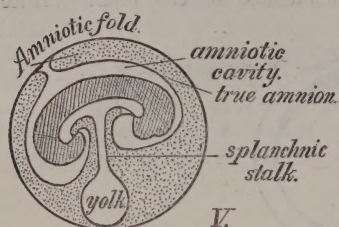


Fig. 17.—Diagram of longitudinal section of later stage, in which the amniotic folds have almost united over the embryo.

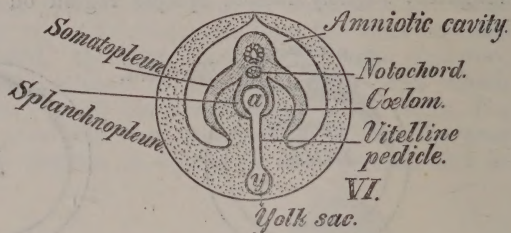


Fig. 18.—Diagram of transverse section of later stage than fig. 17.

11. THE NEURAL CANAL AND VERTEBRAL COLUMN.—While the embryo is being separated from the non-embryonic part of the developing egg,

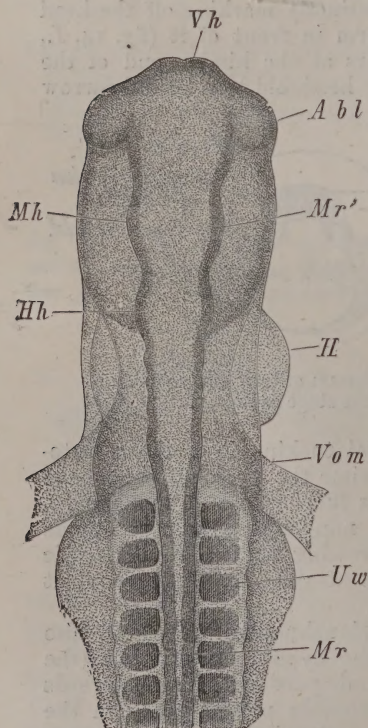


Fig. 19.—Diagram of anterior end of neural canal—*Abi*, optic vesicle; *H*, heart; *Mh*, wall of mid-brain; *Vom*, omphalo-mesenteric vein; *Uw*, protovertebra.

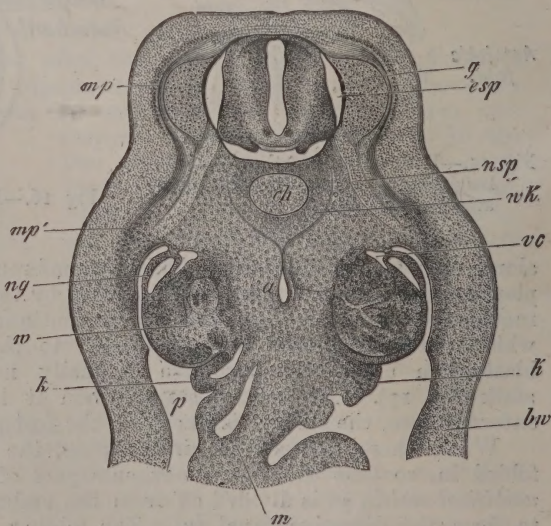


Fig. 20.—Section of embryo, showing formation of vertebral body around the notochord—*esp*, spinal canal; *nsp*, spinal nerve; *vk*, body of vertebra forming around (*ch*) the notochord; *mp*, muscle plate; *a*, aorta; *p*, coelom; *bw*, somatopleuræ.

the medullary groove undergoes significant changes. The front end of the medullary plate has dilated (fig. 9, *III.*, and fig. 12), and the lips of the groove rise and become inflexed (figs. 13, 16, and 18), so that ultimately their margins meet and coalesce in the middle line, converting the groove into a neural canal. Closure begins in that region of the dilated front part where subsequently the mid-brain is to be developed, and extends rapidly both forwards and backwards, so that by the time the amniotic folds have met over the body of the embryo, the neural canal is almost completely closed in. From the layer of epiblast, which is thus shut in as a lining for the canal, the central nervous system develops, the foremost and widest portion of the head is the **anterior brain vesicle** (fig. 19, *Vh*), the second dilatation is the **middle brain vesicle** (*Mh*), while the long, irregular hindmost enlargement, occupying the remainder of the head, is the **posterior brain vesicle** (*Ph*). The lining of that part of the tube behind the head (*Mr*) forms the **spinal marrow**.

The Vertebrae and Muscle-Plates.—The axial skeleton and the primitive muscular system arise from the protovertebrae. Not long after the occurrence of this segmentation (figs. 9, *U*; 12; 13, *m*; and 19, *Uw*) the lines of division fade in the innermost portion of the chain, so that the tissue on each side of the notochord appears as a continuous stripe. This extends inwards and joins its fellow of the opposite side, both above and below the notochord, which it thus encloses (fig. 20). From this a lamella of mesoblast extends into the wall of the neural canal for its entire extent. The tissue which has in this manner formed a complete sheath around the notochord, begins, before the end of the first week, to undergo a secondary segmentation into *permanent vertebrae*, the new planes of division not coinciding with the protovertebral clefts, but being intermediate, so that each permanent vertebra is made up of the contiguous parts of two adjacent protovertebrae.

The remaining portion of the chain of protovertebrae, which lies external to this foreshadowing of the axial skeleton, still retains its primitive segmentation, and to each of its segments the name **muscle-plate** is given (fig. 20, *mp*). Even as late as the commencement of the secondary cleavage in the vertebral column, these still retain traces of the primitive bilaminar arrangement due to the original upward extension into them of the coelom (fig. 13, *b*). The cells of the layer next the vertebral column (splanchnic layer) become elongated, and they early exhibit contractility, thus becoming primitive muscular tissue. Those of the outer or somatic layer become similarly transformed at a later period. As the muscle-plates preserve the original segmentation of the protovertebrae, their planes of division are opposite the middle of the bodies of the permanent vertebrae, and the laminae of clear mesoblast between the contiguous protovertebrae become changed into connective tissue; so, eventually, the muscular fibres derived from one protovertebra become joined to those of their neighbour by a primitive connective intermuscular septum.

The muscular system, like the skeletal, primarily consists of a successive series of segments, but the muscular transformation extends into the mesoblast of the somatopleure beyond the limits of the muscle-plate, and gives rise to the musculature of the body-wall.

12. LIMBS.—On each side of the embryo, at about the end of the second week, two faint rounded ridges appear, which soon enlarge into four round-edged flattened lobes. The fore pair arise opposite the 7th, 8th, and 9th vertebrae; the hinder opposite the 20th-25th, and both consist of tissue derived from several, probably six or seven, segments, and are placed opposite the level of the outer edge of the muscle-plate. A week later, these lobes have become sharply defined in front and behind (fig. 21), and about the end of the fourth week a flexure or joint is apparent in the middle of each limb (4). A week or so later,

the free extremity shows four superficial notches (5), which, by the end of the seventh week, have deepened sufficiently to define the separate fingers and toes.

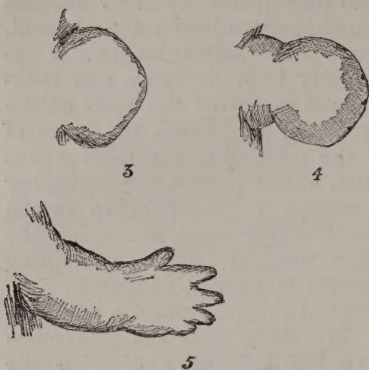


Fig. 21.—Outlines of fetal limbs—3, at third week; 4, at fifth week; 5, at end of seventh week.

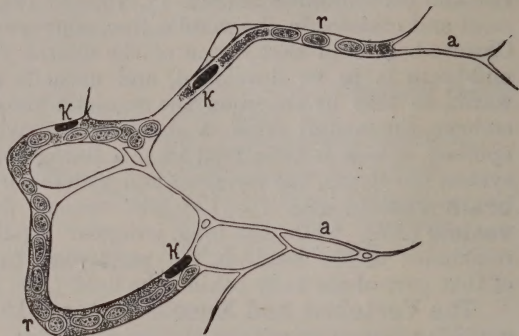


Fig. 22.—Formation of blood-corpuscles in connective cells—*r, r*, the formed corpuscles; *k, k*, nuclei of the vaso-formative cell; *a, a*, processes which ultimately unite to form capillaries.

The surfaces of the primitive limbs are at first dorsal and ventral, and their edges are directed pre- and postaxially.

13. BLOOD AND BLOOD-VESSELS.—(A) When the rising of the

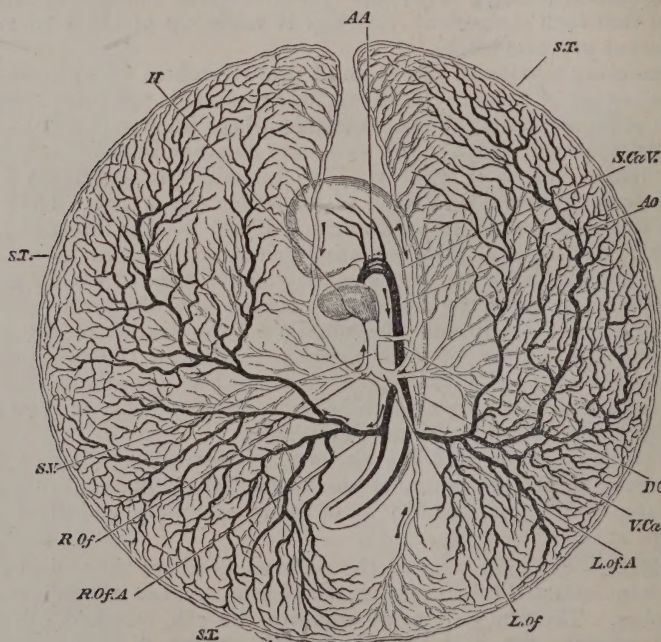


Fig. 23.—Vascular area. The veins are marked in outline, and the arteries are black.—*AA.*, 2nd, 3rd, and 4th aortic arches; *Ao.*, dorsal aorta; *DC.*, ductus Cuvieri; *H.*, heart; *L.of.A.*, left vitelline artery; *L.of.*, left vitelline vein; *R.of.*, right vitelline vein; *R.of.A.*, right vitelline artery; *S.Ca.V.*, superior (ant.) cardinal vein; *S.V.*, sinus venosus; *S.T.*, sinus terminalis.

amniotic folds (fig. 15) separates the extra-embryonic somatopleure from the splanchnopleure, a change takes place in the disposition and structure of the cells of the outlying area of splanchnopleural mesoblast. These become grouped in irregular series and individually vacuolated (fig. 22). When the vacuoles of contiguous cells communicate, there is produced thereby a network of continuous cavities. In these vacuolated cells, portions of the cell-substance become detached, and assume rounded forms and a reddish colour, thus becoming *embryonic blood-corpuscles* (*r*).

In mammals, the primitive corpuscles are formed of the protoplasm of certain cells, rarely by the proliferation of nuclei, as in the bird.

The wall of the vacuolar network becomes more definite, and some corpuscles become adherent to it, while the cell-substance liquefies around the multiplying corpuscles, and forms a viscid fluid or plasma in which they float. The united cells in this manner become a tubular system of anastomosing vessels, filled with a corpusculated fluid. This change involves the splanchnopleural mesoblast for a considerable distance outside the embryo, and the surface so modified is called the *vascular area* (fig. 23). Around its margin a large vein, the *sinus terminalis*, originates (*S.T.*), which takes a nearly circular course, turning inwards anteriorly on each side, so that the vascular area is here indented by a deep bay.

(B) **Heart.**—Before the amniotic folds have risen, the wall of the splanchnopleural mesoblast near the border of the parietal zone, on each side of the region of the mid-brain, becomes folded on itself to form a deep gutter (fig. 24, *h*), whose open border is directed towards the hypoblast, and which subsequently closes and becomes a tube.



Fig. 24.—Section through head of rabbit.

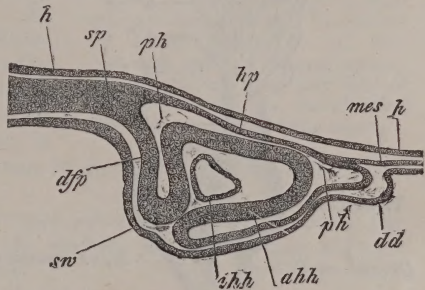


Fig. 25.—Heart groove more highly magnified.

This may be regarded as a subdivision of the coelom into two parts, a *hæmocœlom* or vascular system, and a *metacœlom*, the remaining part of the body cavity.

As the splanchnopleure becomes folded inwards to form the splanchnic stalk, the front ends of these two hæmocœlomic tubes are folded in towards

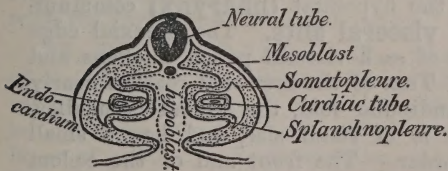


Fig. 26.—Convergence of the two heart tubes.

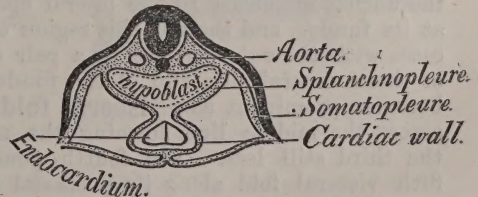


Fig. 27.—Coalescence of the heart tubes.

each other (fig. 26), and they ultimately come in contact in the medio-ventral

line of what is to be hereafter the throat of the embryo, in front of the splanchnic stalk and below the pharynx. These tubes then coalesce (fig. 27), and form a single sinuous tube, the **primitive heart** (fig. 23, *H.*), which receives the blood from the sinus terminalis and other vessels from the vascular area through a short trunk on each side, the **omphalo-mesenteric vein** (fig. 19, *Vom*). From the front end of this primitive heart (fig. 28) there pass several (five) pairs of tubes, the **aortic arches**, which loop around the front end of the hypoblast, and unite posteriorly on each side into a trunk, the **dorsal aorta**, which runs tailward, giving off branches. The two dorsal aortae ultimately coalesce into one median trunk.

The larger vessels begin as solid cords of mesoblastic cells, whose central core becomes hollowed by vacuolation.

The vascular system is the first of the newly formed parts to take on its duties, as it becomes functional as soon as it is formed. The blood-corpuscles oscillate in the vessels shortly after their first appearance, and the heart begins to contract, even before its cells have assumed the distinctive appearance of muscle.

14. DIGESTIVE ORGANS.—(A) That portion of hypoblast which is included in the body of the embryo, assumes a tubular form in front and behind the splanchnic stalk. The anterior part ends blindly a little in front of the heart, extending into the mesoblast of the neck, which has not participated in the cleavage into splanchno- and somatopleure. From each side of this foremost

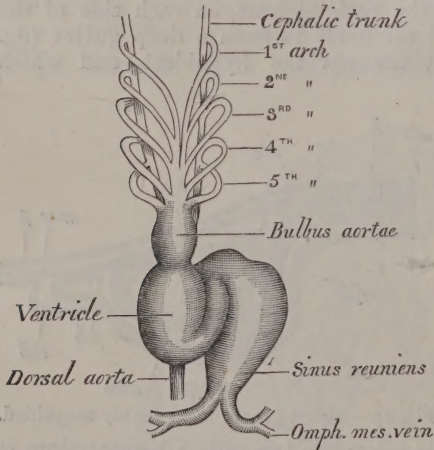


Fig. 28.—Primitive heart and aortic arches.

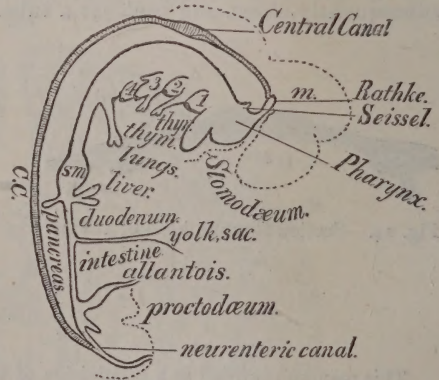


Fig. 29.—Diagram of digestive canal of embryo—lateral view.

end, four small **visceral pouches** (1, 2, 3, and 4, fig. 29) extend through the uncleft mesoblast to the lateral epiblast, the foremost becoming perforated at its fundus, and thereby this region of the hypoblast (**pharynx**) communicates with the outer surface by a pair of **visceral slits**. The preaxial edge of these visceral slits and of the fundus of each visceral pouch thickens and becomes prominent as a **visceral fold**. That of the first cleft reaches nearly across the middle line, forming the mandibular fold, the second is smaller, the third still less. The fourth pouch is of small size, and has a small fifth visceral fold along its postaxial border. The front end of the coelom extends forwards for some little distance under the pharynx, though not on its sides, and the several aortic arches arising from the heart traverse this space and enter the uncleft mesoblast of the visceral folds.

From the ventral surface of the pharynx opposite the second, third, and fourth visceral pouches respectively there arise three outgrowing pouches, the foremost giving origin to the **thyroid body**, the middle to the **thymus**, and the hindmost, which from its beginning consists of two small budding tubes, to the **lungs** (fig. 29).

The tube of hypoblast on the dorsal side of the heart remains narrow and forms the **œsophagus** or gullet. On the postaxial side of the heart the hypoblast expands to form the **stomach** (*sm.*), behind which is a short **fore-gut**, which ends at the attachment of the splanchnic stalk (whose expansion is represented as cut in the diagram where it joins the yolk sac, and from whose upper end or duodenum the **liver** and **pancreas** arise as outgrowths. Below the region of the splanchnic stalk, the hypoblast is also tubular, forming the terminal part of the intestine, which inferiorly shows a trace of its prolongation into the **neurenteric canal** which communicated with the obliterated blastopore below and with the central canal (*C.C.*) of the spinal cord dorsally; but this post-anal gut speedily vanishes, leaving the intestine closed behind.

(B) **Proctodæum**.—A pit-like invagination, the **proctodæum** (fig. 29), lined by epiblast, extends inwards from the surface beneath the tail fold opposite the blind end of the hypoblast, into which its fundus ultimately opens, thus making the **anal opening**. In cases where the proctodæum is undeveloped or misses the hypoblast, the foetus presents the condition of *imperforate anus*, which at birth requires surgical treatment. In such cases a weak cord, the obliterated post-anal gut, is often recognisable, and is sometimes sufficiently distinct to be a useful guide to the surgeon.

(C) **Stomodæum**.—A similar but deeper invagination of epiblast, the **stomodæum**, is pushed in anteriorly in the middle line below the anterior brain vesicle (represented by a dotted line in fig. 29), and in front of the first visceral fold. It reaches the ventral surface of the pharyngeal region of the hypoblast, above which its fundus is prolonged to terminate beneath the middle brain vesicle (*m*). On the absorption of the partition between the stomodæum and the pharynx, the anterior end of the digestive canal communicates with the surface by the mouth cavity.

15. THE HEAD AND FACE.—The wall of the cerebral vesicles consists from without inwards of an external layer of epiblast, a middle layer of mesoblast, and an included layer of epiblast. From the two outermost are derived the scalp and skull, from the innermost the tissues of the nervous system.

The anterior brain vesicle (fig. 30, *v*) becomes acutely bent downwards and forwards around the front end of the notochord, which here terminates

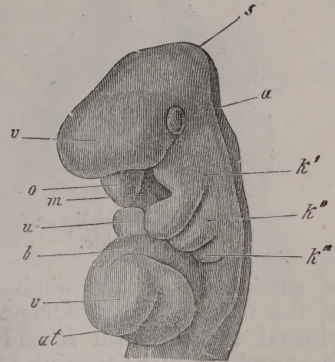


Fig. 30.—Profile outline of embryo rabbit of ten days $\times 10$ —*a*, eye; *at*, primitive auricle of the heart; *b*, aortic bulb; *k*, *k'*, *k''*, 1st, 2nd, and 3rd visceral arches; *m*, mouth; *o*, maxillary lobe of the right side; *m*, mandibular lobe; *v*, ventricle of the heart.

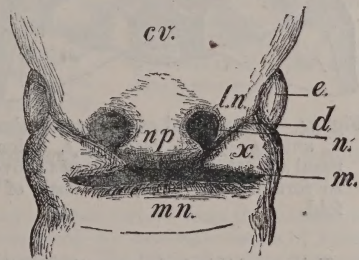


Fig. 31.—Facial processes of foetus of the fourth week.

beneath the floor of the middle vesicle (*s*). Owing to this **anterior cranial flexure**, the middle vesicle becomes topmost in the head. In the middle of the posterior vesicle a second or **Varolian flexure** appears (on the level of *k'*); and, a little later, a third or **cervical flexure** (on the level of *k''*) marks the limit between the hindmost vesicle and the spinal cord.

At the end of the third week, three deep pits, lined by epiblast, become depressed on each side of the head, and ultimately come in contact with outgrowths from the developing brain, and thus give rise to the organs

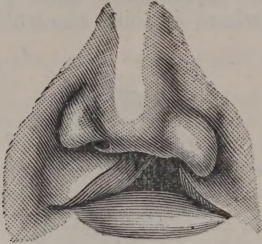


Fig. 32.—Hare-lip on the left side.

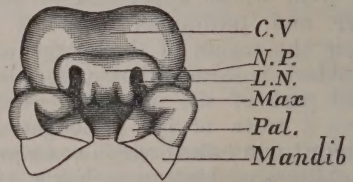


Fig. 33.—Foetal head, nearly four weeks old, cut through the stomodæum.

of special sense. The hindmost forms the **auditory vesicle** at the level of the front of the hindmost brain vesicle, and above the base of the first visceral slit (between *k'* and *k''*). The second or **optic vesicle** (*a*) is in front and above the opening of the stomodæum (*at, m*), and the third or **nasal vesicle** (fig. 31, *n*) is farther forward, close to the middle line, and at first united to the stomodæum by deep furrows; hence the border of the head, which forms the upper edge of the oral invagination below the anterior brain vesicle, presents, at the fourth week, five marginal **facial processes**. The central of these is the single **fronto-nasal process** (fig. 31, *np*), which

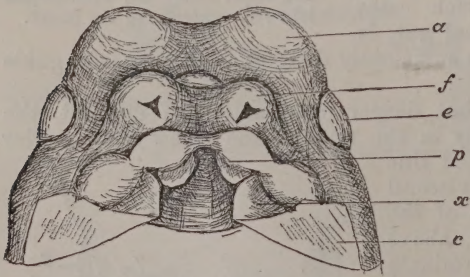


Fig. 34.—Foetal head of five weeks similarly cut—*a*, anterior brain vesicle; *f*, union of fronto-nasal and lateral nasal processes above, projecting to form the nose; *c*, cut basis of mandibular fold.

is separated on each side from the **lateral nasal process** (*ln*) by the nasal invagination (*n*). External to the lateral nasal process is the ocular invagination (*e*), at the outer and inferior border of which an outgrowth from the mandibular fold, the **maxillary process** (*x*), grows forward (fig. 33), separating the ocular invagination from the stomodæum. As it extends, its inner edge touches and coalesces with the outer side of the fronto-nasal process, making thereby a continuous upper lip for the aperture of the mouth (fig. 34).

Failure of this fusion constitutes the malformation called *hare-lip* (fig. 32).

The union of the lateral nasal and fronto-nasal processes internally completes the edge of the anterior opening of the nostril, while the thickening of these processes forms the nose. The lower edge of the oral invagination is made by the mandibular fold (*mn*), which lies in front of the first visceral cleft, and in which the lower jaw is subsequently formed. These partitions between the nasal invagination and the mouth are at first superficial, but an ingrowing

process from the maxillary process on each side (fig. 33, *Pal.*) eventually extends inwards like a shelf to meet its fellow of the other side (fig. 35, *p*) medially and the vertical septum which grows down from above (fig. 35, *s*), and these shut off the nasal fossæ and complete the roof of the mouth (*c*).

Failure in the development, or want of median union of these partitions, produces the malformation called *cleft palate*. The hinder extension of the middle nasal process, which takes part in the formation of the palate (fig. 34, *p*), is the premaxillary process.

16. UROGENITAL APPARATUS.—Before the appearance of the limbs a long row of cells (seen in section in fig. 36 at *w.d.*) becomes differentiated on each side, close to the outer border of the muscle-plate (*m.s.*), and on a plane between the aorta (*ao.*) and the cardinal vein (*ca.v.*), as a cord which extends for almost the whole length of the body, ending behind at the level of the proctodæum. This is at first solid (fig. 13, *w*), but soon becomes tubular, developing a lumen. From comparison with corresponding structures in lower animals, this can be identified as the **mesonephric** or **Wolffian duct**, the duct of a middle system of segmental tubes (fig. 20, *ng*). In the mesoblast of the intermediate cell-mass between the muscle-plate, the aorta and the mesothelium of the cœlom (*s.p.*), secondary cords (becoming tubular) develop around this tube (*st.*) nearly at right angles to the longitudinal duct, and with their inner extremities at first attached to the mesothelium. These are the **mesonephric tubules**, and collectively form the **Wolffian body**. A second tube, the **pronephric** or **Müllerian duct**, beginning as a column of cells in contact with the wall of the Wolffian duct, appears a little later (fig. 37, *I., M*), and like the mesonephric duct (*W*), is continued backwards to open into the proctodæum (*S*) in the female (*II.*, fig. 37), while in the male it remains rudimentary and nearly vanishes (*III.*, *h*). No traces of pronephric or anterior segmental tubules have been found in the human embryo.

About the fourth week the **ureter** arises as a diverticulum from the postaxial part of the mesonephric duct, and extends forwards into the tissue at the postaxial end of the intermediate cell-mass, wherein tubules form, some of which are outgrowths from the ureter. The whole mass of tissue around the end of the diverticulum becomes condensed into an ovate mass, the **metanephros** or **kidney**, whose shape and structure become apparent before the beginning of the third month.

The urogenital system consists of specialised segmental tubes derived from the metameric excretory system of a simpler ancestral form, which consisted of a successive series of tubes that opened from the cœlom on the surface of each metamere. The tract of surface whereon they opened has become first a groove, and finally a canal; hence, the primitive main duct is probably epiblastic in origin, while the tubules are mesoblastic.

17. FŒTAL MEMBRANES.—(A) **Allantois.**—From the postaxial end of the ventral surface of the splanchnopleure, a narrow process of mesoblast grows downwards at the back of the splanchnic stalk (fig. 29). A very small outgrowth of the hypoblast, with an inappreciable cavity, extends into this (fig. 38, *c*); but the chief mass of the outgrowth is mesoblastic. This process,

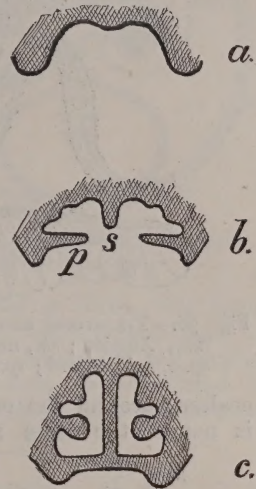


Fig. 35.—Coronal sections through nasal fossæ showing successive stages of closure of the communication between the nasal fossæ and mouth, and of the nasal fossæ of the two sides by the down growth of the septum, *s*, and the ingrowth of the palatine shelf of the maxillary process, *p*.

which is named the **allantois**, extends into the hinder part of the elevated fold of the amnion. We have already seen that the amniotic folds rise and

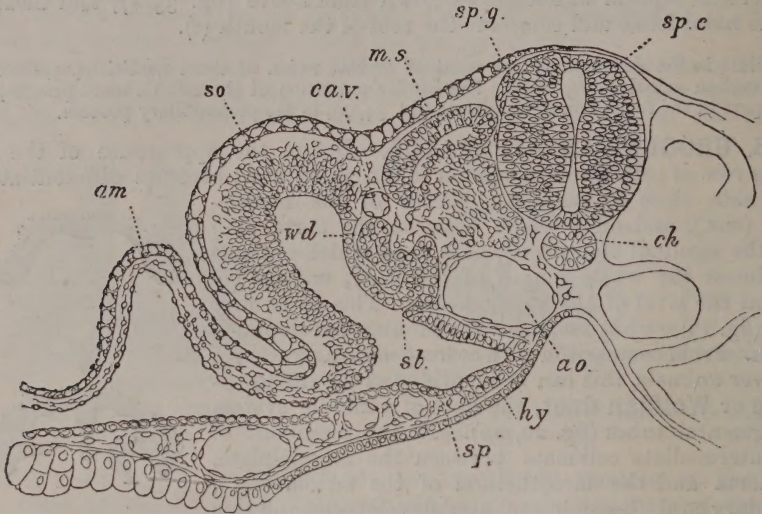


Fig. 36.—Transverse section of duck embryo, showing formation of Wolffian duct—*am.*, Amnion; *ch.*, notochord; *hy.*, hypoblast; *so.*, somatopleure; *sp.*, splanchnopleure; *sp.c.*, spinal cord; *sp.g.*, spinal ganglion; *st.*, segmental tube; *w.d.*, Wolffian duct.

coalesce around the embryo (figs. 15, 17, and 18), and that the inner layer is named the **true amnion**, and is continuous with the edges of the

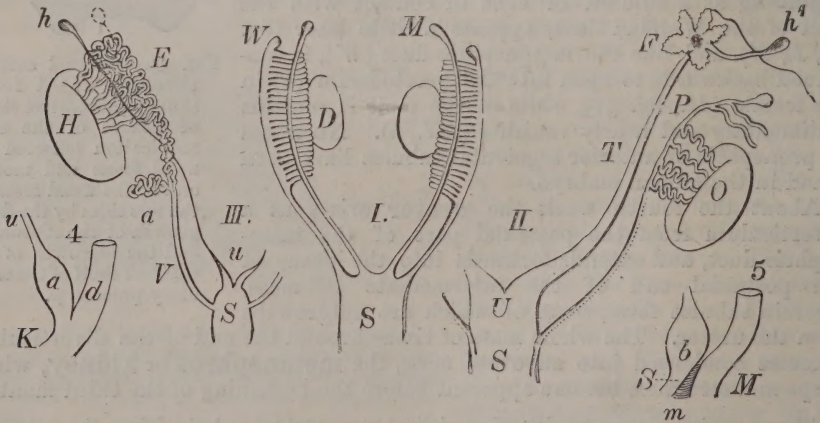


Fig. 37.—Diagram of components of the urogenital apparatus.—*I.* Undifferentiated condition—*D*, reproductive gland; *W*, Wolffian duct; *M*, Müllerian duct; *S*, urogenital sinus. *II.* Transformations in the female—*F*, fimbria with the hydatid, *h'*; *T*, Fallopian tube with its terminal hydatid, *h'*; *U*, uterus; *S*, urogenital sinus; *O*, ovary; *P*, parovarium. *III.* Transformations in the male—*H*, testis; *E*, epididymis with the hydatid, *h*; *a*, vas aberrans; *V*, vas deferens; *S*, urogenital sinus; *u*, male uterus. 4. *d*, hind-gut; *a*, allantois; *u*, urachus; *K*, cloaca. 5. *M*, rectum; *m*, perineum; *b*, position of bladder; *S*, urogenital sinus.

somatopleure. This consists of epiblast and a thin layer of mesoblast. The outer layer or **false amnion**, which is now separated from the true

amnion, and which has coalesced below with the epiblastic capsule of the umbilical vesicle, consists, for most of its extent, of little else than epiblast, and is called the **subzonal membrane** (fig. 38, *sz*), because it lies inside the villous outer envelope of the egg, the **zona radiata** (fig. 14). Into the space between the true amnion and the subzonal membrane, the solid extension of the allantois projects and expands beneath the subzonal membrane, uniting with it to form an outer composite membrane, the **chorion** (fig. 39, *ch*). The allantois carries with it two large arteries from the lower division of the aorta, and returns its blood by two allantoic veins, one of which becomes subsequently obliterated. Branches of these vessels spread in the chorion, and extend into the *villi* (fig. 38, *pc*), which clothe its surface.

(B) **Decidua**.—The mucous membrane lining the uterus (fig. 39, *u*) or maternal cavity of the parent, when it is occupied by a developing embryo, becomes thickened and increases in vascularity, and as the inner layer of this membrane is shed with the fœtus at birth, this layer receives the name **decidua**. The thickening of the mucous membrane is greatest in that area which comes in contact with the chorion at the region of attachment of the stalk of the allantois. In this area the membrane is called the **decidua serotina** (fig. 39, *d.s.*). Folds of the mucous membrane project from the edges of the *d. serotina*, and closely invest the rest of the chorion, forming the **decidua reflexa** (*d.r.*), while the rest of the membrane, separated from the chorion by these folds, is the **decidua vera** (*du.*). The long and branched villi clothing the chorion are at first generally distributed over almost its whole surface (*z'*); but the increasing growth of the fœtus, and the increasing amount of fluid in the amniotic cavity, press this layer outwards and interfere with the growth of its vessels, so that the villi soon become restricted to the area opposed to the decidua serotina, which is called **chorion frondosum** (*z*), and atrophy elsewhere, leaving the rest of the chorion bare (**chorion læve**, *ch.*). The villi of the chorion frondosum become complexly branched, and sink into the irregularities of the surface of the uterine mucous membrane, becoming inseparably connected with the decidua serotina, and forming by this fusion a solid cake-like vascular mass, the

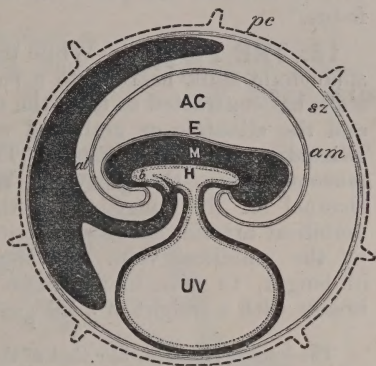


Fig. 38.—Diagram showing formation of the allantois.

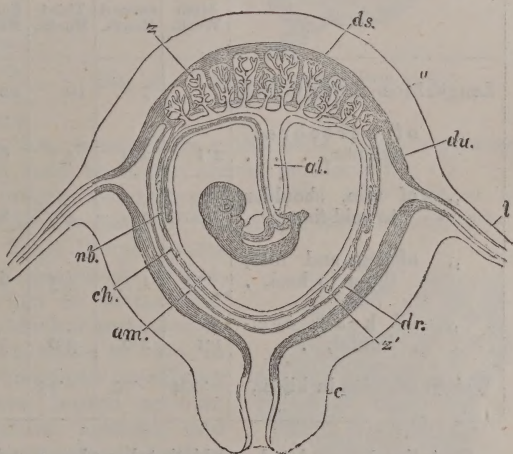


Fig. 39.—Diagram of the fœtus and its membranes *in situ*—*al.*, allantoic stalk (urachus); *am.*, amnion; *c*, cervix uteri; *ch.*, chorion; *l*, Fallopian tube; *nb.*, yolk-sac; *z*, fetal villi of the true placenta.

placenta, which thus consists of two elements, fetal and maternal, and in which the maternal blood of the decidua by transudation contributes nourishment to the vessels of the allantois, and thence to the fetus. Ultimately the chorion laeve, decidua reflexa, and d. vera, unite over the remaining surface around the placenta, and form one indivisible "membrane of the fetus."

18. THE FŒTUS.—While these changes of envelope are taking place, the splanchnic stalk narrows to a rudiment, the *omphalic pedicle*, and the somatic stalk has contracted to form the *umbilical cord* (*a.l.*), which contains this pedicle and the allantoic or umbilical vessels (now enormously enlarged, and spirally twisted around each other). The allantoic tissue around them has become mucous tissue, the **jelly of Wharton**, and the cord now serves as the channel for the nutrition of the fetus; its impure blood passing by the umbilical arteries to the placenta, and the purified blood returning therefrom by the umbilical vein. At the period of birth this cord averages 50 cm. in length, 12 mm. in thickness; it is invested by a sheath of amnion, and breaks with a weight of 5 kilograms.

The human placenta, like that of the catarrhine monkeys, is derived from that part of the expanded allantois which is opposite the ventral surface of the fetus. To this type of placenta the name *metadiscoidal* is applied.

This short sketch of the evolution of the external form and principal systems of the fetus will serve as a useful introduction to the detailed examination of the structure of the adult. The rate of growth of the fetus is even more liable to vary than that of the adult, but the average dimensions at different periods are as follows:—

TABLE SHOWING RATE OF GROWTH OF FŒTUS.

	Sixth Week.	Second Month.	Third Month.	Fourth Month.	Fifth Month.	Sixth Month.	Seventh Month.	Eighth Month.	Ninth Month.
Length in cm., crown to heel,	...	7	16	22	27	30	42	47	51
„ of vertebral column, . . .	2'1	2'9	4	6'6	10'2	11'0	12'4	15'0	18'4
„ of arm, shoulder to mid-finger, .	'80	2	4'5	8'5	10'5	13'5	14'0	15'0	16'5
„ of leg and foot, ilium to heel, .	'70	1'75	4'5	6	11'0	12'5	12'9	16'2	17'2
„ of head, occipital, . . .	1'1	2'0	3'0	3'8	6'0	7'5	8'4	9'5	10'8
Weight of fetus in kilos.,	'004	'02	'13	'28	'63	1'2	1'8	2'25	3'15

Gestation is completed and birth takes place usually at the end of 280 days.

HISTOLOGY.

19. THE TISSUES which make up the human body may be grouped into five classes—1st, **epithelial**, or surface-limiting; 2nd, **connective**, or skeletal; 3rd, **nervous**, or sensory; 4th, **muscular**, or contractile; 5th, **blood and lymph**, or nutritive.

20. EPITHELIUM.—This is the most archaic of tissues, being descended with but little modification from the primary layers of the developing ovum. It consists of cells placed side by side so as to form continuous lamellæ; these, by clothing every free surface in the body, prevent the escape of lymph, impart smoothness, furnish protection to underlying parts, and in some situations are modified so as to become the instruments of secretion or of sensation. The cells are nucleated, invested with a cell-wall, and have neither lymph- nor blood-vessels between them, and scarcely any intercellular substance. They are usually placed on the surface of a *basement membrane* (fig. 41, *a*), beneath which blood-vessels and lymph paths are abundant. While in many situations epithelium is highly metabolic, short-lived, and rapidly renewed, in others the protoplasm is largely converted into metaplastic material, such as eleidin, keratin, &c.: the cells in consequence are low in metabolism and vitality, and, therefore, almost permanent.

Being exposed to so many diverse conditions, epithelial cells present a corresponding variety of form. They are flat, and in a single lamella, united by thin edges when required only to limit lymph spaces (fig. 40). They are arranged in successive strata, with flattened superficial cells, when on surfaces exposed to vertical pressure (fig. 47); thicker and column-like when lining canals which are liable to vary in calibre (fig. 41). The general conditions modifying the cells are—superficial pressure, lateral tension, rate of metabolism, and the nature, amount, and direction of flow of the material habitually in contact with their free surface. However much modified, nearly all epithelial cells agree in essential characters, such as the presence of the large regular oval or rounded nucleus, and the disposition of the nuclear and extra-nuclear network.

21. GLANDS.—The protoplasm of certain epithelial cells possesses the property of *secretion*. When provided with abundant nutriment, the molecules of protoplasm in the cell construct some protoplasm-derivative, correlated to

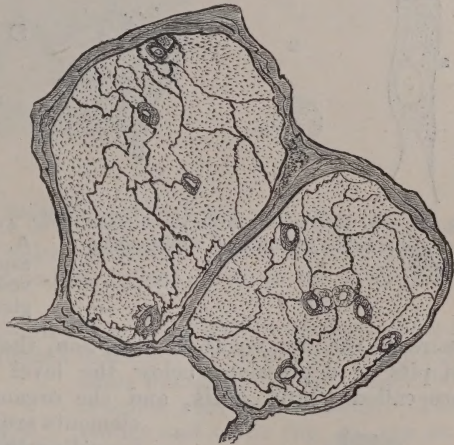


Fig. 40.—Pavement epithelium in air-vesicle of lung.

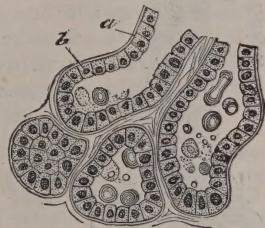


Fig. 41.—Cubical epithelium in the acini of the mammary gland — *a*, membrana propria; *b*, epithelium.

the conditions of the surface with which they are connected; and this is given out by exudation or rupture, on the application of some stimulus. To favour the nutrition and consequent metabolism in secreting cells, as well as to

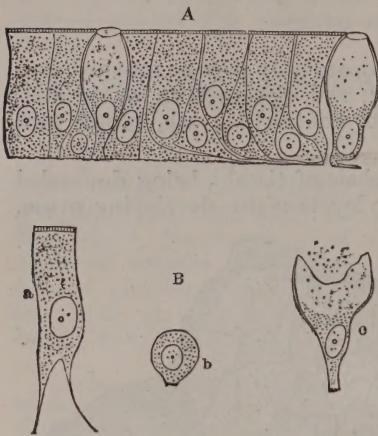


Fig. 42.—A, Epithelium from the surface a villus in the jejunum; B, replacement cells.

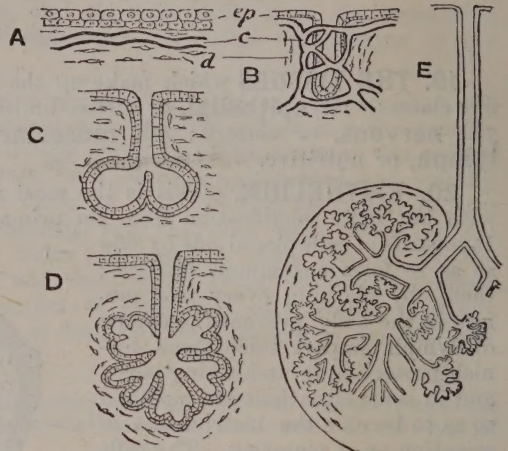


Fig. 43.—Diagrams of different kinds of glands—A, scheme of skin; ep, epidermis; d, cutis, with capillary (c); B, simple gland with blood-vessels; C, D, more complex glands; E, compound gland (omitting blood-vessels).

increase the area for their reception, they are usually arranged on the walls of pits or depressions below the level of the general surface. Such cells are called **gland cells**, and the organs of which they are the functional elements are called **glands**. Glands are classified according to the complexity of their organisation.

1. **Unicellular.**—When single secreting cells are scattered in the epithelium of a continuous surface, we may regard them as unicellular glands. Of this sort are those mucus-secreting cells (fig. 42, c), which are found scattered among the columnar cells (a) in the wall of the intestine, in which the superficial part of the cell becomes charged with mucus, distending it, and pushing the nucleus and shreds of unaltered protoplasm to the foot of the cell, which is often constricted to a stalk. When such a cell ruptures, it appears somewhat wine-glass shaped, and is called a **goblet cell**.

It is difficult to determine whether these cells rupture during life or not, and how far the goblet form is a *post-mortem* appearance due to reagents.

2. **Simple Tubular Glands.**—Simple pits lined by gland cells (fig. 43). These tubes may be (1) straight, as in the peptic glands of the stomach (fig. 43, B); (2) coiled, as the sweat glands (fig. 160); (3) acinous, in which the tube ends in a sac (**acinus**), to which the gland epithelium is limited, as in the sebaceous glands of the skin (C, D).

3. **Racemose Glands** (E) are those in which the gland-tube is branched,

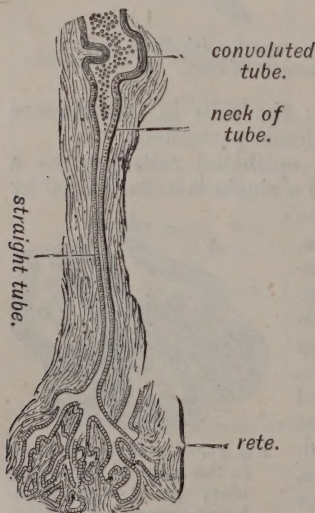


Fig. 44.—Convoluted tube of testis opening into straight tube.

and each branch ends in an acinus. In these the function of secretion is limited to the acinus, and the tube or *duct* which conveys the secretion out of

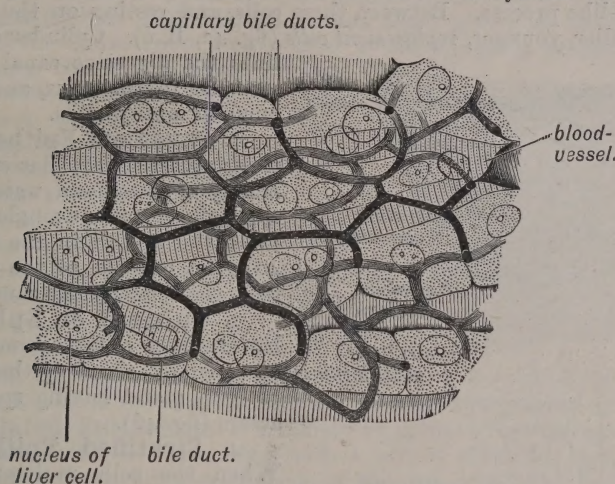


Fig. 45.—Diagram of finest ducts of the liver.

the gland is lined by less metabolic cells. Racemose glands may be *simple*, such as the Meibomian glands of the eyelids, or *compound*, as the lachrymal, salivary, or pancreatic glands (E).

4. Compound Tubular Glands.—In these the secretory surface, instead of being consolidated into acini, is extended to form a series of very elongated, often branching, tubes, united by vascular connective tissue. The kidney and testis (fig. 44) are examples.

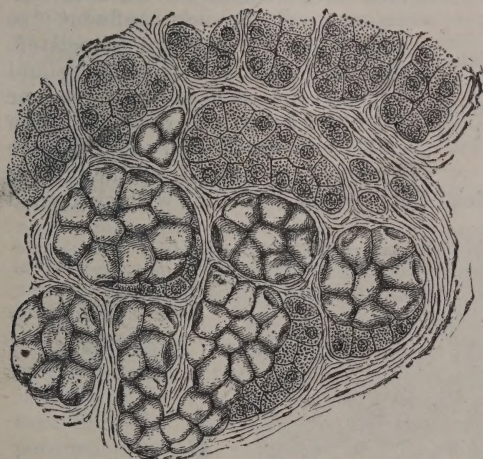


Fig. 46.—Cubical epithelium of submaxillary gland. The cells are two-fold; the lower are mucous-secreting, the upper are aquiparous.

5. Lobular Glands.—The most complex gland in the human body, the liver, although tubular in its earlier stages, loses that character in the course of development, owing to the overgrowth of the cell-masses, and ultimately consists of lobular clusters of gland cells, between which are tubular intercellular passages which form the radicles of the ducts (fig. 45).

To the ducts of some glands, reservoirs are appended for the temporary reception of their secretions; the gall-bladder and vesiculæ seminales are examples. These are periodically emptied by contraction of the walls, or by external pressure.

22. CLASSIFICATION OF EPITHELIUM.—The forms of epithelium in the human body are:—

1. Cylinder Epithelium (fig. 42, B, a), whose cells are columns, higher than broad, often conical or prismatic from mutual pressure, placed side by side, and for the most part in one layer. Their free surfaces are sometimes

indurated into a cuticle-like layer of metaplastm, marked with very fine radial striæ. Their attached ends are often longitudinally striated, or expanded into a foot or beak-like process. Between these cells, and resting on the basement-layer, are smaller, younger, *replacement cells* (fig. 42, B, *b*). Cylinder epithelium lines the digestive canal from the stomach to the anus, and lines the ducts of most glands.

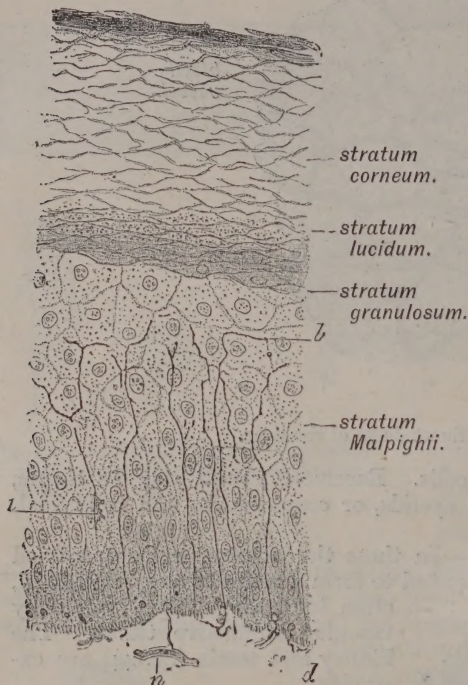


Fig. 47.—Stratified epithelium from the skin—*n*, cutaneous nerve; *b*, nerve ending; *d*, corium.

2. **Pavement Epithelium** consists of irregular, flattened cells, mostly of metaplastm, united edge to edge, and forming a single layer. It lines the alveoli in the lungs (fig. 40), the capsule of the crystalline lens, the semicircular canals, &c.

3. **Cubical or Spheroidal Epithelium** is the commonest form assumed by gland epithelium, that of each gland having special characters (fig. 46).

4. **Stratified Epithelium.**—When the cells multiply rapidly, they build up a tissue of several layers, of which the deeper or newer cells are columnar or cubical, while the older layers become flattened as they approach the surface. In these layers the cells are irregular, and the metaplastic walls of contiguous cells become confluent; so that, when the cells are dissociated, the former points of union stand out on the surface as ridges or prickles; hence the cells are often called *prickle cells* (fig. 162). Where stratified pavement epithelium is exposed to pressure, the dried superficial cells become scale-like, with shrivelled



Fig. 48.—Transitional epithelium from the bladder.

nucleus and no spines or prickles, and hardened by infiltration with keratin or

eleidin, forming by their confluence a cuticle. Stratified epithelium constitutes the superficial layer of the skin, of the pharynx, cesophagus, vagina, &c.

5. **Transitional Epithelium** is the name given to those forms which partake of the characters of two or more of the foregoing groups. It occurs in many places, the best marked is that modified, stratified form which lines the ureter and bladder (fig. 48), consisting of (1) large club-shaped cells, whose narrow ends rest on the basement membrane. In the intervals between these are (2) smaller irregular cells; while (3) large, flattish, cubical, often multinuclear, cells are moulded on the free surfaces of the first series, each flat cell extending over the ends of several of the deeper cells. This form is correlated with the varying conditions of distention of the organ.

6. **Ciliated Epithelium** is a variety of cylinder epithelium in which the free surface of the cell is clothed with a tuft of vibratile, hair-like processes, continuous with the inner protoplasm of the cell, capable of wavy motion, and bending in a definite direction either below their middle or at their base.

The structure of cilia is imperfectly understood, many of the minuter appearances described being probably the result of the action of reagents. Each cilium consists of a fine, somewhat flattened, apparently structureless process, beginning in a slightly dilated *basal end*, which is fixed by a narrow *intermediate portion* to a short rod, either attached to, or penetrating, the clear non-contractile disk on the surface of the cell, from which fine reticulated fibrils penetrate the protoplasmic network of the cell. Ciliated epithelium lines such passages as are traversed by air, or by secretions containing solid particles. Cilia average about $\cdot 008$ mm. in length, the largest being those lining the tube of the epididymis. The cells lining the bronchial tubes have the most numerous cilia (20-25) on each cell; those of the central canal of the spinal cord have the fewest, and are the smallest.

Ciliated epithelium lines the nasal and lachrymal passages, the Eustachian, Fallopiian, and bronchial tubes, &c. In some of these regions this epithelium is stratified, in the smaller bronchi it is one-layered. Ciliated pavement epithelium is found on the floor of the tympanic cavity; and pavement cells with short, soft, non-vibratile processes lie in patches on the choroid plexus in the fetal brain.

7. **Sensory Epithelium.**—Into many superficial epithelial cells nerve filaments can be traced (fig. 47, *b*); indeed, it is not improbable that all sensory nerves terminate in epithelium. In the organs of sense-perception peculiar epithelial cells bearing stiff processes, which differ in characters according to the nature of the vibrations to which they are exposed, are found connected with the terminations of the nerve fibres (fig. 50).

The membranes clothed with epithelium are skin, mucous membranes, and the brain cavities. The cells which line serous membranes and blood-vessels, although dissimilar in history, are comparable in structure and function with epithelium. New epithelial cells arise by karyokinesis from the deeper pre-existing cells, which lie in contact with the basement membrane.

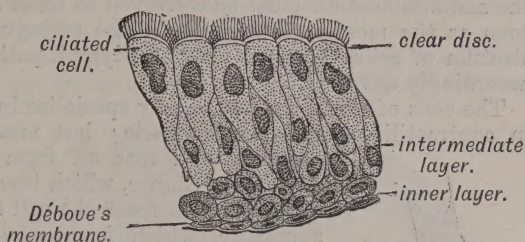


Fig. 49.—Ciliated epithelium from the trachea.

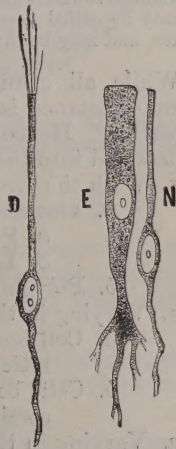


Fig. 50.—Olfactory epithelium from the superior turbinate bone—*E*, nasal epithelium; *N*, modified cell with nerve filament; *n*, olfactory cell from frog.

23. CONNECTIVE TISSUES.—When cells are so disposed that they are in contact with nutrient fluids by one surface at least, they do not require any special mechanism for their nutrition; but when they have multiplied to form solid masses which are shielded by mutual contact from external nutriment, the assimilable fluid must be conveyed to them by special channels. Hence, as soon as the mesoblast thickens in the embryo into a tissue of more than one stratum of cells, the need arises for lymph paths and a vascular system, which accordingly develope.

The cells of the mesoblast chiefly specialise in two directions; some increase in contractility and become muscle; but most of them become irregularly flattened and cast off from their surface the outer layer of their substance, which becomes converted into metaplasma, and separates from the cell to form an intercellular ground-substance, which is traversed by wall-less lymph paths; while the remaining part of the cell itself sends off processes, either lamellar or branched, the nucleus becomes flattened, and, with the small amount of unaltered protoplasm which surrounds it, shows an intracellular and intranuclear network. Cells of this kind are named *connective tissue cells*, and the tissues wherein they are found are called *connective tissues*. These tissues form the framework of the whole organism; they are low in grade of metabolism, and (except in the case of bone) scanty in their vascularity, although they serve as the media for the conveyance of vessels to the other tissues.



Fig. 51.—A connective tissue cell.

Connective tissue cells, wherein most of the material has become metaplasma, are flattened, and may be called *lamellar cells*, while those which contain much unaltered protoplasm are thicker, and may be called *plasma cells*.

While all connective tissue cells exhibit a strong family likeness, the ground-substance is variable in amount, chemical composition, and mechanical properties. Hence the forms of connective tissue are numerous, and may be classified into the following groups:—

1. With the forms of the cells themselves modified:
 - a. Flattened to form a continuous layer, lamellar cells—
 - α. Supporting a layer of epithelium, . = Basement membrane.
 - β. Lining canals or cavities, . = Endothelium.
 - b. Polygonal plasma cells infiltrated with fat, = Adipose tissue.
2. Varying in the form and arrangement of the cell-processes:
 - a. Cell bodies distinct, with much branched reticulated processes, . = Adenoid tissue.
 - b. Cell bodies indistinct, metaplasma becoming parallel bundles of fibres, . = Fibrillar tissue.
3. Varying in the nature of the ground-substance:
 - a. Ground-substance mucoid in appearance and containing albumen, . = Mucous tissue.
 - b. Ground-substance containing elastin, . = Elastic tissue.
 - c. Ground-substance containing chondrogen, = Cartilage.
 - d. Ground-substance calcified, containing collagen, . = Bone.

The circumstances determining the production of special forms of connective tissue are more easily understood than the mechanism of their differentiation. Where firmness is needed, there bone develops; where elasticity, firmness, and smoothness of surface, there cartilage; where simple toughness and flexibility, there fibrillar tissue forms. The most abundant form, areolar tissue, is a mixture of fibrillar and elastic tissue; other mixed varieties exist in the body.

1. **Basement Membrane.**—Beneath the epithelium of most mucous membranes there is a layer of flattened connective cells, sometimes so closely united that their boundary lines are indefinite and with difficulty brought out by reagents (fig. 41, *a*). This membrane is traversed by lymph spaces, and is always thin, though sometimes firm, as in the trachea; in other membranes it is reduced to a network, as in the salivary glands.

2. **Endothelium.**—Basement cells in some places simulate the overlying epithelium, and thus form an easy transition to cells of this class which are indistinguishable from true pavement epithelium, although mesoblastic in origin. The name “endothelium” is applied to such cells as line intramesoblastic cavities, *e.g.*, blood-vessels, serous and synovial membranes. Endothelium is always one-layered, with flattened nuclei, and the cells may be polygonal, elongated, or irregular.

Cilia may be present, though rarely, as on the end of the Fallopian tube, and sometimes (in serous membranes) the endothelium is interrupted by small groups of polyhedral radiated cells surrounding fine perforations, or *stomata*, opening into the subjacent lymph paths. The distinction between “endothelium” and “epithelium” is not always either histologically certain or functionally possible, nor can its development be relied on as a criterion, for the genito-urinary epithelium is apparently of mesoblastic origin.

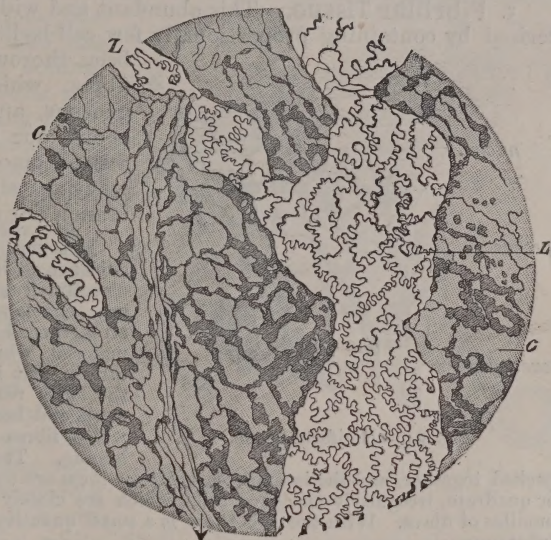


Fig. 52.—Endothelium from the diaphragm—*L*, lymphatic vessel with wavy-edged endothelial lining; *c*, endothelium of surface.

3. **Adipose Tissue** consists of closely packed, polyhedral, connective cells, whose protoplasm has become charged with fatty matter; the nucleus (fig. 53, *n*) and the unaltered shreds of protoplasm being compressed and often almost obliterated.

As fat is derived from the breaking up of protoplasm, it can only develop in such cells as have a substantial protoplasmic body. Most ordinary connective cells have undergone too much metaplastic transformation to allow of any large development of fat in them; hence fat cells are rarely branched. The degree of fat distention varies, from the presence of a few oil globules (fig. 53, *a*), to the complete conversion of the whole cell-contents (*c*). The fat consists of stearic, oleic, and palmitic acids, combined with glycerine, and is fluid during life, becoming solid after death. Fat cells measure about .05 mm. in diameter, and are found in clusters, encapsulated by areolar tissue in which capillary blood-vessels ramify. The first trace of fat is seen in the fœtus of the thirteenth week. In the adult, fat is distributed through the meshes of the subcutaneous areolar tissues in all regions except the eyelids, scrotum, and penis, in all places where spaces exist between organs, or where there are intervals between muscular sheaths.

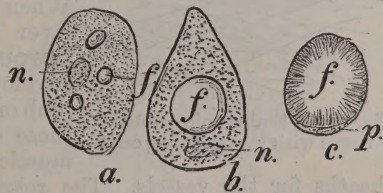


Fig. 53.—Fat cells—*f*, fat globules.

4. **Retiform or Adenoid Tissue** is that form of connective tissue whose

cells are for the most part extended into much-branched anastomosing processes, making a close network of filaments and lamellæ, in whose meshes lies a liquefied, slimy, but seldom mucin-holding ground-substance (fig. 54).

As the meshes of this tissue freely communicate with all the surrounding lymph paths, they abound in leucocytes, for which they constitute the most appropriate breeding-place; hence this tissue is closely connected with the lymphatic system. It is little else than a very generalised variety of areolar tissue, abounding in leucocytes.

5. Fibrillar Tissue.—This abundant and widely diffused tissue is characterised by containing proportionally few cell-bodies, as most of the cells have been thoroughly transformed into white fibres, which are transparent, homogeneous, and doubly-refracting, ranging about $\cdot 002$ mm. in diameter, united by a small amount of unaltered matrix into wavy parallel bundles, which neither branch nor anastomose.

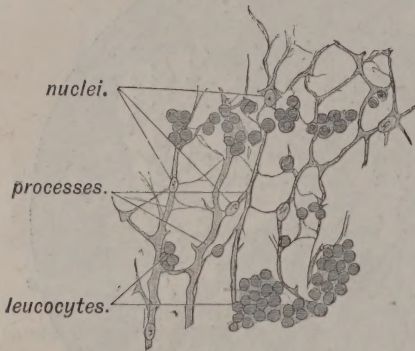


Fig. 54.—Retiform tissue.

It is not easily proved, although there is evidence to indicate, that the fibres originate directly from cells. The primitive bundles are enveloped in sheaths that are often strengthened by engirdling rings of a different material, which can be stained red by picrocarmin, but is unaltered by acetic acid, while the latter reagent makes the fibres themselves swell and become indistinct. The material of white fibres resolves itself into gelatine on boiling. These bundles are generally closely packed together, and the interspaces between them are occupied by single files of flattened or quadrate, irregularly-margined cells, which are closely applied to, and moulded on, the bundles of fibres. With the cells there is a small quantity of semi-fluid, unaltered ground-substance.

This tissue is strong, inelastic, and resisting; a cord 1 square mm. in cross-section bore a weight of 8,940 grammes before it broke. Its surface has a nacreous sheen, owing to the interference effects of the reflected light from the wavy bundles. Small portions of this tissue have few vessels; larger cords or sheets are permeated by layers of areolar tissue containing vessels.

Bands of fibrillar tissue fastening bones together are called **ligaments**; if they unite muscular fibres to bones, they are **tendons**. Each tendon is surrounded by a layer of very fine areolar tissue, whose superficial cells are flattened on the surface of the tendon to form an endothelium, thus enabling it to glide during muscular contraction. When interlaced fascicles are flattened into a thin layer investing other parts, they constitute a **fibrous membrane**. An expansion of this kind, enveloping the muscles, vessels, and nerves of a limb or region, is called a **fascia** or **aponeurosis**; these send in partitions between the contiguous muscles (**intermuscular septa**), and form sheaths for the vessels. The relations of these fasciæ are of great practical importance in Surgery.

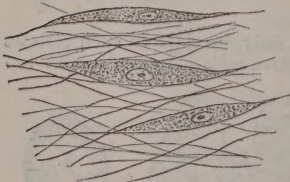


Fig. 55.—Embryonic fibrillar tissue with transforming cells.

6. Mucous Tissue consists of cells, either spindle-shaped or with branched anastomosing processes, which form a network in an abundant semi-fluid, homogeneous, ground-substance, through which only a few leucocytes wander, and in which a few fibrils are traceable.

It is essentially an embryonic tissue, and occurs as the Whartonian jelly in

the umbilical cord before the eighth month, and in a few other localities in the fetal body. In course of development, it increases in fibrillation and becomes areolar tissue, while its spindle cells become fatty. In the adult it only remains, though modified by the disappearance of its cells, in the vitreous humour of the eye.

7. **Elastic Tissue** is a tough, yellowish material, made up of transparent, singly refracting, branching and reuniting filaments, polygonal in section (fig. 56), curling at the ends when broken, not united into close, parallel, skein-like bundles. They range from .001 to .006 mm. in thickness, and are unaffected by acetic acid or boiling. Sometimes this tissue is lamellar (fig. 57), the branching and uniting fibres being flattened into a fenestrated membrane, as in the lining of blood-vessels.

When closely massed together, these yellow fibrils make up highly elastic ligaments, such as the interlaminae ligaments of the vertebrae. A band of this tissue 1 square mm. in cross-section broke with a weight of 4,040 grammes, and before breaking its length had increased 65 per cent.

Areolar Tissue, the most widely diffused substance in the body, consists of white and yellow fibres mixed in varying proportions, together with spindle-shaped and lamellar branching cells, showing gradations of all kinds, from the simple cell to the white fibril. When immature there is an abundant gelatinous ground-substance uniting the elements, but this shrinks in the adult, and the tissue becomes spongy, pierced by the gaps and spaces from which its name is derived.

The density of this soft elastic material varies according to the number, sizes, and closeness of texture of the white fascicles which usually cross each other in all directions in its substance. Elastic fibrils are disposed either between or on these white fibres, and flattened

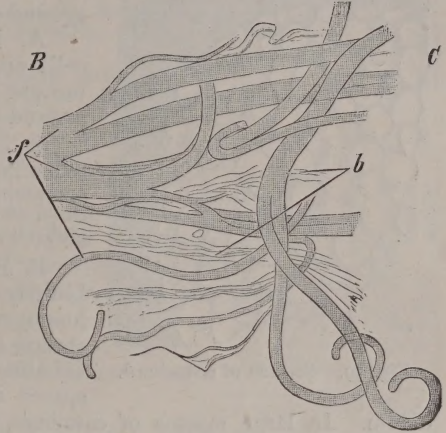


Fig. 56.—Elastic tissue—*f*, coarse fibres; *b*, finer fibrils.

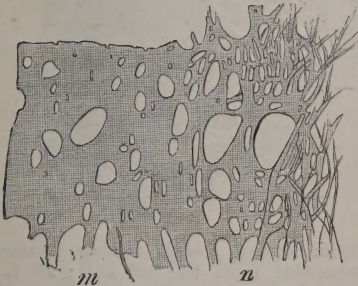


Fig. 57.—Fenestrated membrane of elastic tissue—*m*, becoming fibrillar at *n*.

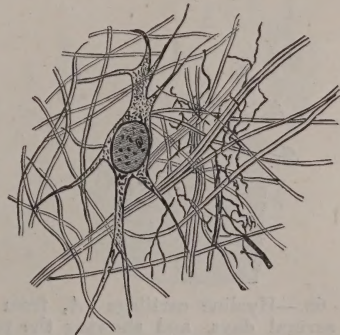


Fig. 58.—Areolar tissue.

connective cells are dispersed in the intervening meshes. Areolar tissue is universally diffused in and around all the other tissues of the body, and as its areoles freely communicate with each other, air or fluid can be made to pass through its meshes. The art of dissection

consists in the complete removal of this tissue from around the other structures, so as to expose the parts enwrapped therein.

Yellow fibrils arise in the embryo in the form of lines of granules, which appear in the ground-substance of connective tissue, and which subsequently coalesce to form fibres.

8. **Cartilage** or **Gristle** is a firm, elastic, bluish-white, translucent substance, consisting of connective cells embedded in a solid ground-substance, which yields chondrin on prolonged boiling. Four forms of cartilage can be distinguished according to the amount and texture of the ground-substance.

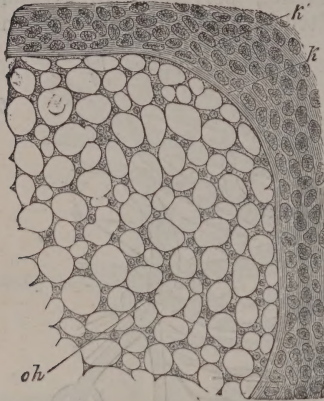


Fig. 59.—Section of notochord.

A. **Parenchymatous Cartilage**, whose cells are closely packed, having between them minute lymph paths and a minimal amount of ground-substance (fig. 59, *ch*).

The notochord and the substance of the foetal skeleton before the fifth week consist of this material, which in appearance resembles a vegetable tissue. Its cells, like those of other varieties of cartilage, often include oil-globules or granules of glycogen.

B. **Hyaline Cartilage**, in which oval or bluntly-angular cells are enclosed in a copious homogeneous or faintly granular ground-substance (fig. 60, *g*), pervaded by minute lymph canaliculi, which communicate with lymph spaces around the cells and in the perichondrium. In large masses of cartilage, there are macroscopic clefts containing processes of areolar tissue and blood-vessels, but no capillaries can be detected in the substance of the cartilage itself. All cartilages, except the layers which encrust the articular ends of bones, are surrounded by a laminated fibrillar membrane, the **perichondrium**, in which many blood-vessels ramify.

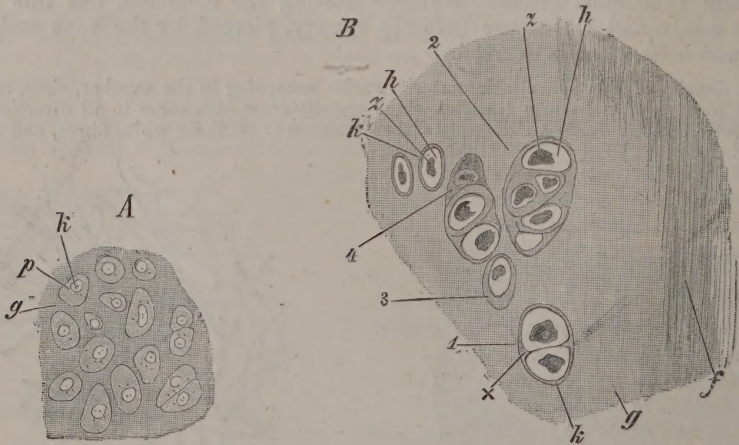


Fig. 60.—Hyaline cartilage—A, from frog; B, from human costal cartilage macerated several days, and showing the protoplasm separated from the cell-wall; at 1, two cells (*z*) are within one capsule (*k*); at 2, five cells (one has fallen out) are within the one capsule; at 3, the capsule is obliquely cut; at 4, it is not opened, and the cell shines through.

Some hyaline cartilages are *temporary*, being precursors of the bones of the adult skeleton; others are *permanent*, such as the gristles of the nose, larynx,

and ribs, and those coating the joint-surfaces of bones. In these last, which are called **encrusting cartilages**, the cells closest to the bone are in vertical columns, those which are superficial lie parallel to the surface, while the intermediate cells are irregular in disposition (fig. 61).

When softened by maceration, the ground-substance breaks up into fibres which lie in the direction of greatest pressure. Although apparently homogeneous, yet the superficial and deep portions of a mass of articular cartilage appear anisotropic by polarised light, while the intermediate tracts are isotropic. These optical appearances are probably correlated to varying degrees of condensation or tension. The refractive index of the structure immediately around the cell is lower than that of the cell or the rest of the ground-substance.

The ground-substance of that portion of articular cartilage which is in contact with bone often becomes calcified by the deposition of bone-earth (fig. 61). Costal cartilage may either calcify or ossify. Nasal cartilages rarely calcify. The cells close to the margin of articular cartilage are often branched and irregular, being transitional to the ordinary connective tissue cell.

C. Reticular Cartilage is opaque, yellowish, and highly elastic, having its matrix traversed by a copious interlacement of yellow elastic fibrils. It is found in the external ear, epiglottis, Eustachian cartilage, and the vocal process of the arytenoid.

These begin their existence as hyaline cartilages, in which the elastic fibres appear first as granules around the cells, extending in lines from the perichondrium.

D. White Fibro-cartilage consists of layers of white fibrous bundles between which encapsulated cartilage cells are scattered.

The proportional number of cells varies in different parts of the mass, both in reticular and in white fibro-cartilage. In the former the meshes are closer, and the hyaline material less abundant in the centre than at the surface. Where the latter is attached to bone, its cells are fewest.

Fibro-cartilage is tougher and more flexible than hyaline, but less yielding than reticular cartilage, and is generally disposed in small masses which may be (1) *interarticular*, a plate interposed between two bones, from which its surfaces are separated by joint-cavities (fig. 78);

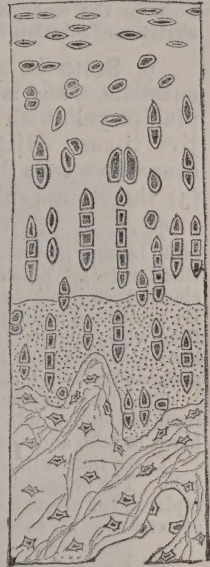


Fig. 61.—Section of encrusting cartilage.

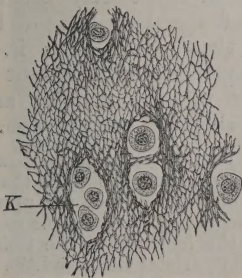


Fig. 62.—Reticular cartilage—K, nest of cartilage cells.

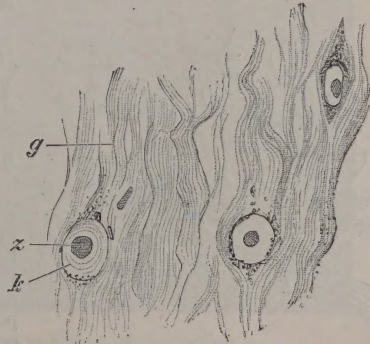


Fig. 63.—Fibro-cartilage—g, white fibres; k, capsule of cell, z.

(2) *symphyseal*, a plate interposed between bones, to the surfaces of which it is firmly attached (fig. 75); (3) *marginal*, forming a lip around a joint-cavity to deepen it (fig. 79); (4) *theal*, lining the sheaths of tendons; and (5) *sesamoid*, a thickening developed in a tendon.

All cartilages except the notochord are mesoblastic in origin, and are at first made up of closely compacted polyhedral cells with distinct nuclei and clear margins, from which the ground-substance is a differentiation. Cartilage differs from the other connective tissues in its greater condensation; a strip of hyaline cartilage 1 mm. in section broke with a weight of 1,440 grammes, of reticular 1,760, of white 2,300. When divided during life, cartilage unites by the formation of cicatricial connective tissue, becoming eventually fibro-cartilage. Broken cartilages unite by similar tissue, and often become surrounded by a bony ring of *callus*. Cartilage is historically older than bone, though newer than fibrillar tissue. It existed in many invertebrates, in the lowest vertebrates, and preceded bone in the embryo. In the past history of animals, bone first appears in the dermal skeleton of Silurian fishes.

9. **Bone** is, with the exception of enamel, the hardest of all organic substances, and is remarkably elastic and tenacious. During life it is whitish-pink or yellowish in colour, and more vascular than other varieties of connective tissue. Histologically, bone consists of three elements—(1) branched connective cells (bone cells—fig. 64, *c*); (2) interlacing and decussating fibres; (3) the ground-substance, in which lime salts are deposited.

The mineral matter may be removed from bone by maceration in dilute hydrochloric acid (still better, in a mixture of 2 per cent. of nitric and $\frac{1}{2}$ per cent. of chromic acid with distilled water). When thus decalcified, bone is softer, tougher, and more flexible, but less elastic than hyaline cartilage; retaining its shape and size, but losing two-thirds of its weight. By prolonged boiling the animal matter is resolved into gelatine, identical with that derived from white fibrous tissue. This animal matter is very persistent in old bones, 13 per cent. having been found in an ulna from a long barrow, and 14 per cent. in the vertebra of a mummy at least 3,400 years old.

The remaining two-thirds of bone consist chiefly of phosphate of calcium, and can be freed from the animal substance by calcination in a free current of air. The residuum is white, hard, brittle, and usually diminished in bulk.

These lime salts are probably united with the albuminoids of bone in a compound molecule. The practical constancy of composition of the ground-substance, the possibility of the replacement of some of the calcium by strontium, and the impossibility by prolonged boiling of extracting all animal matter from bone, are evidences of this; but the union is a feeble one.

The percentage composition of bone is usually—

Collagen (animal matter),	. . . 31.03	Calcium fluoride and other salts,	. . . 1.41
Calcium phosphate,	. . . 58.23	Magnesium phosphate,	. . . 1.32
Calcium carbonate,	. . . 7.32	Sodium chloride,	. . . 0.69

The trifling variations in the results of different analyses depend on the different amounts of the three histological elements in different bones, and on the difficulty of divesting bone of the fat, vessels, &c., that enter into it. The degrees of hardness of different bones depend rather upon molecular arrangement than on chemical composition.

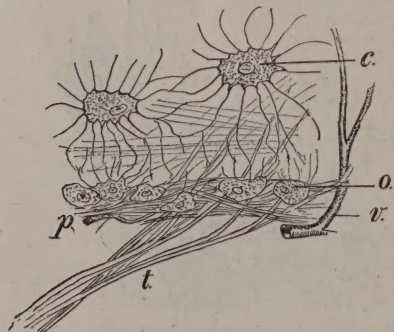


Fig. 64.—Section of the surface of a decalcified bone—*t*, tendon.

Long bones contain more ground-substance and mineral matter, but less fibre than those of the trunk, and the bones of the upper limb than those of the lower, the humerus more than the radius, and the femur than the tibia. The inner table of the parietal bone and the petrous portion of the temporal have the highest percentage of mineral matter. The composition of fully-formed bone varies very little with age. When all adhering unossified material is removed, the proportions are the same in the radius of a

fetus at birth, a child of seven, an adult of forty, and an old man of eighty.

24. CLASSIFICATION OF BONES.—Bones are commonly divided into *long*, as those of the limbs, *flat*, as those of the skull, and *short*, or those

that belong to neither of these categories. Long bones have hollow shafts (**diaphyses**), and articular extremities, which ossify independently of the shafts, and which, before their union therewith, are called **epiphyses**.

25. PERIOSTEUM.—Every recent bone is invested with a laminated fibrous membrane (**periosteum**—fig. 64, *p*), whose outer layer consists of closely-interwoven bundles of white fibres, with a little elastic tissue in its deeper portion, having fat-cells and blood-vessels (*v*) included in its meshes. Its inner or osteogenetic layer consists of loosely reticulated white fibres, among which are scattered spheroidal connective cells (**osteoblasts**—fig. 64, *o*), which take part in the formation of new bone.

In early life the cells of this layer multiply rapidly, so that the whole layer is thicker, softer, and more easily detached than in the adult; much of this tissue becomes eventually ossified, and thereby bone grows in thickness.

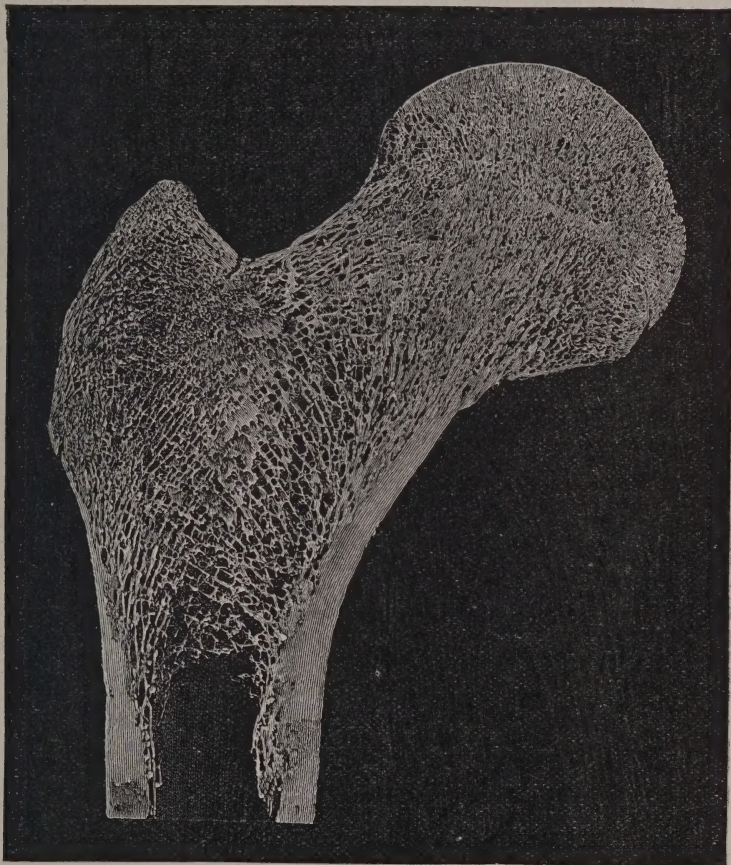


Fig. 65.—Cancellous tissue of the head of the femur.

The **arteries** of periosteum form close-meshed networks, and enter the bone through the numerous holes in its surface. It is by these that the bone is nourished: consequently, detachment of periosteum during life is often followed by the death of the uncovered bone. Each vessel carries with it a delicate fibrous sheath, by which the membrane is closely bound to the bone.

Periosteum is closely attached to spongy bones, and to the extremities of long bones, especially at the lines of junction of the epiphysial cartilages. It is also closely adherent to prominent points of bones, and to the areas of insertion of tendons; the fibres of these are continued through it as perforating fibres, into the substance of the bone. Into some of the attached ends of tendons, osteoblasts occasionally spread between the tendon fibres; hence ossification sometimes extends into these tissues.

The arrangement of the fibres of the outer layer of periosteum is constant and definite for each bone. In the osteogenetic layer of the shafts of long bones in the adult, the cells become flattened, and sometimes form a nearly continuous endothelioid layer, with lymph spaces between the membrane and the bone; hence the easy separability of the periosteum from these parts. The fibres always remain thick and strong around lines of epiphysary union; even when the ligamentous purpose which they at first subserved is superseded. In old persons the periosteum becomes thin and its vessels scanty, as ossification has involved the whole deeper layer, and the membrane becomes separable with difficulty. On the bones bounding the tympanic and nasal cavities, the mucous membrane becomes inseparable from the periosteum. No membrane covers the articular ends of bones, nor the surfaces where two bones are tied together by an intervening plate of fibro-cartilage.

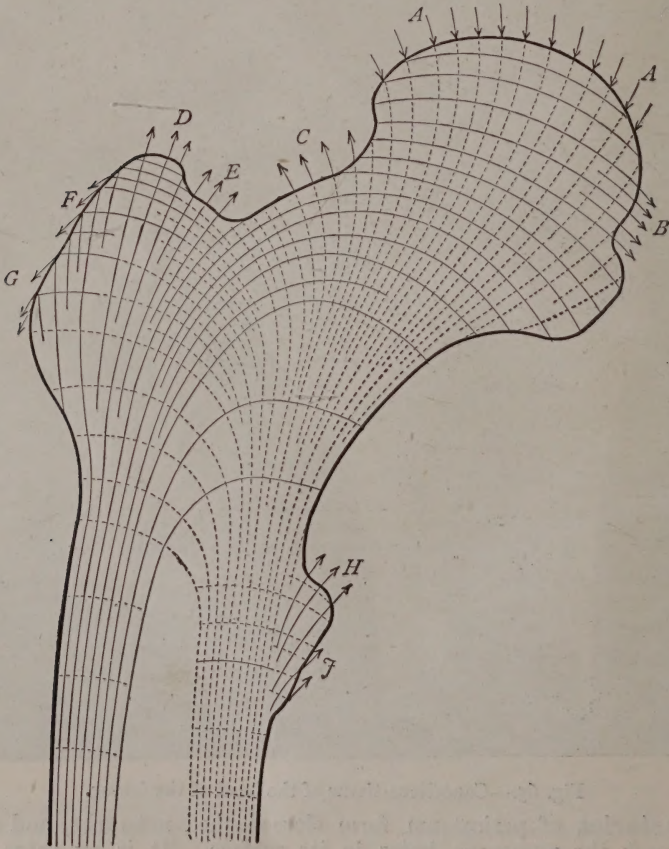


Fig. 66.—Lines of stress in section of neck of femur. *A A*, area upon which thrust of the body-weight comes; *B, C, D, E, F, G, H, J*, areas of traction. The dotted lines are strut-lines bearing the vertical thrust, the continuous lines are the tie-lines of tension.

26. STRUCTURE OF BONE.—The texture of bone is permeated by fine anastomosing channels called **Haversian canals** (fig. 67), varying from $\cdot 125$ to $\cdot 02$ mm. in diameter, each containing an artery derived from the periosteal vessels, a vein, often of large size, and one or more minute nerve-twigs, surrounded by lymph spaces. In the compact tissue of long bones, these canals are cylindrical; but towards their extremities, or in short bones, they dilate into irregular spaces in which the vessels are surrounded by marrow, the bony boundaries of the canals being reduced to thin lamellæ, or to a mere lattice-work of bony spicules (fig. 65). In these spaces the veins and arteries often run separately, and the former escape alone through large apertures near the articular ends. According to the sizes of these canals, bone tissue is called *compact*, or *cancellous*; the former is dense, with cylindrical Haversian canals, little larger than the vessels which traverse them; the latter is spongy, made up of the netted spicules which bound the marrow-holding dilatations of the vascular canals.

The arrangement of the cancelli in each bone is correlated to the mechanical conditions of the bone, and requires special note in each. There are two chief types—(1) **round-meshed**, as in the rounded heads of bones exposed to pressure in all directions, and (2) **orthogonal**, with two sets of bony lamellæ, one in the direction of greatest pressure, the other in the direction of greatest tension; these intersect each other nearly at right angles, and are coarser or finer according to their circumstances. In the coarser lamellæ, fine Haversian canals may exist. Those of the neck of the femur are shown in fig. 65.

Most of the arteries contained in Haversian canals lose their muscular coats; the veins are thin-walled, and provided with imperfect valves. The vascular channels are for the most part constant in direction in different parts of bones. In the shafts of long bones, the largest run in a nearly longitudinal course, and are connected by cross branches to form elongated meshes; the canals are wider towards the marrow cavity than towards the outer surface of the bone, and present all intermediate gradations from the single canal to the cancellous mesh. In flat bones they run nearly parallel to the surface, and in each short bone there is one definite direction in which the largest canals run. No vascular canals exist in very thin bones, such as the lachrymal, all the vessels of which ramify in the periosteum. Lymph spaces abound in the periosteum and around the Haversian arteries.

Minute Structure.—A thin section of the shaft of a well-macerated, compact bone, ground to transparency, and quickly mounted in thick Canada balsam, exhibits a lamellar arrangement; the plates being disposed in the following series:—

1. **Haversian Lamellæ.**—Three to ten concentric rings, each about $\cdot 006$ mm. thick, surrounding each Haversian canal (fig. 67). Each group of lamellæ,

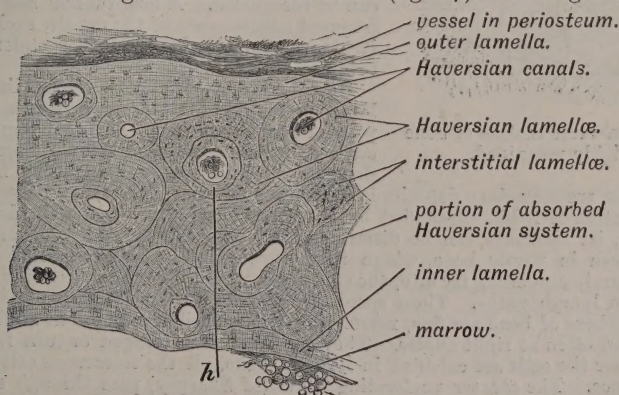


Fig. 67.—Transverse section of bone magnified.

with its canal, is called a **Haversian system**, and has usually a distinct, though rarely a regular, outline.

2. **Interstitial Lamellæ.**—Irregular, detached fragments filling the inter-spaces between the Haversian systems; the remains of earlier lamellæ which have been partially absorbed.

3. **Outer Fundamental Lamellæ.**—Circumferential layers underlying the periosteum, and surrounding all others (fig. 67).

As the Haversian arteries of the shaft have to pierce these last, no Haversian lamellæ surround the vessels until they have traversed these lamellæ. The vascular canals piercing these outer lamellæ are called "Volkmann's canals."

4. **Inner Fundamental Lamellæ.**—Those which surround the central marrow cavity, which may be regarded as a gigantic Haversian system. These layers are seen to best advantage in a transverse section.

In the transverse section of a Haversian system, a large number of irregular, flattened, oval cavities, called **lacunæ**, appear concentrically disposed around the central canal (fig. 68, *Hc.*). From the surface and edges of these lacunæ, pass numerous minute and often branched tubules called **canaliculi**, which traverse the lamellæ, and communicate with the neighbouring lacunæ and with the Haversian canal, forming a network of lymph paths permeating the entire bone.

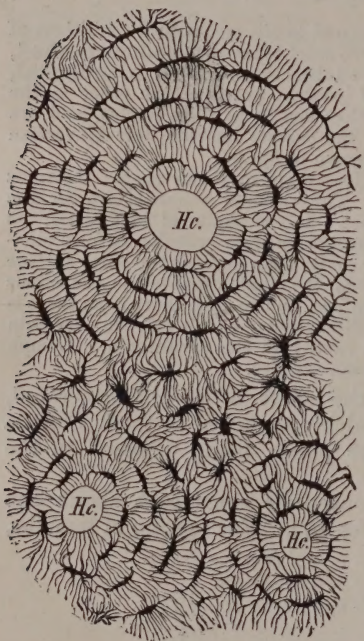


Fig. 68.—Transverse section of bone more highly magnified.

The average lacuna is $\cdot 012$ mm. long, $\cdot 004$ broad, $\cdot 003$ thick. The canaliculi measure $\cdot 0014$ in diameter. The innermost canaliculi of each system open into the central canal, the outermost communicate sparingly with those of other systems, but generally turn back to open into other lacunæ of the same layer. In the fundamental lamellæ, the lacunæ are disposed parallel to the surface of the bone.

Cancellous Tissue.—The structure of cancellous tissue can best be shown by filling the cancelli with a strong solution of gum arabic, which is then hardened by being soaked in alcohol and dried. Fine sections can then be cut and ground to transparency on a hone moistened with alcohol. The cancelli are irregular canals, never blind cells, and gradations between the regular canals and the cancelli can be recognised. A longitudinal section shows the frequent anastomoses of the canals, each bordered by its Haversian lamellæ, and surrounded by parallel columns of narrow lacunæ.

Here and there irregular spaces, lined with new lamellæ, interrupt Haversian systems in both compact or cancellous bone, having irregular spaces as centres, which may be filled with amorphous lime deposits, or irregular lacuna-holding masses not in

lamellæ. These are secondary deposits in absorption cavities (fig. 67).

If a fine section of fresh, decalcified bone, washed clear of acid, be stained with logwood or picrocarmin, its elements can be discriminated. The cells lie in the lacunæ, which they do not fill—even in young bone, where they are largest. Each cell sends off processes opposite, but rarely extending far into, the canaliculi, which, like the spaces around the cells in the lacunæ, are lymph paths. These spaces are lined by a resisting substance resembling keratin. The fibres of bone are fine, resembling white fibrillar tissue, but stiffer, straighter, and decussating, often at right angles. They can be seen in scraped or torn fragments, and neither they nor the cells are calcified in healthy bone, all the calcareous salt being in the ground-substance. The coarser perforating fibres (of Sharpey) pass through several sets of lamellæ, which they bind together, and most of them can be traced externally through the periosteum into tendons.

The ground-substance, which forms the largest part of bone-material, is structureless or faintly granular, permeating and uniting the bundles of fibres.

The appearance of lamination in the Haversian system is due to the disposal in different

directions of the fibres of the bone, whose divided ends, when cut across, give a granular appearance to the layer. When the section is in the plane of the fibres, the lamella appears clear, or finely striated. When seen by polarised light with crossed prisms, the striated layers appear clear and bright, as connective fibres are doubly refracting when light traverses them at right angles to their long axes. The granular lamellæ, being singly refracting, appear black; and as light is also stopped by those fibres which lie parallel to the axes of either of the Nicols, so there appears a black cross over the system, whose centre is on the canal, and whose arms extend at right angles to the edge of the system. The lacunæ which lie in the clear or striated lamellæ appear long and narrow, being divided along their long axes; those in the granular layer are broad, short, and oval, being cut along their short axes; some are inter-lamellar and more irregular.

Marrow.—Around the vessels in some cancellous bones, there lies a network of soft connective cells, whose branching processes entangle in their meshes cells of varying sorts—pale amœboid cells, with oval or lobate nuclei, leucocytes, large and small, the mother cells of red corpuscles, with and without nuclei, fat cells, and polynuclear giant cells. This tissue is called **red marrow**, and it is traversed by large-looped, thin-walled, often perforated vessels. This tissue exists in most fetal bones, and persists in the adult in the heads of the femur and humerus, vertebrae, ribs, and the hip-bone. It contains 72 *per cent.* of water, 2 of fat, 22 of albuminoids, and 4 of salts. In this tissue red blood-corpuscles are supposed to be formed.

Gelatinous Marrow.—In old persons the marrow in the cancellous spaces of the bones of the head is pale and gelatinous, containing but little fat and few blood-vessels. This is called “gelatinous” marrow.

Yellow Marrow.—Filling the hollow in the shafts of long bones and the larger cancelli, is a third variety of marrow, the most purely fatty tissue in the body, whose vessels are few and small, and whose cells are almost completely distended with fat. Its percentage composition is—fat, 95; albumen, 1; water and salts, 4.

The medullary canal is lined by a fine connective layer called **endosteum**, but this is incapable of being detached as a continuous layer, and rarely takes part in bone formation.

27. FORMATION OF BONE.—There are two methods whereby bone is formed in the embryo. The simpler of these is the ossification of immature connective tissue, and is called **parostosis**. The tissue at first appears as a mass of mesoblastic cells, from which a copious intercellular substance is early differentiated. In this ground-substance a reticulated system of blood-vessels forms, and bone fibres appear in bundles, often decussating each other. Each of these **osteogenic fibres** is fibrillated, the component strands being united by a small amount of ground-substance in which calcareous particles first become laid down *between* the fibrils, giving to the fibre a dark granular appearance. The subsequent rapid extension of the deposit into the ground-substance *around* the fibre, unites the neighbouring fibres into a spicule of bone. Peculiar connective cells (**osteoblasts**) are abundantly dispersed among the fibres, and become enclosed in the increasing mass of solidifying tissue, in which the separate fibres soon cease to be recognisable, and the tissue, which at first appeared granular, becomes clear.

In this stage the bone forms a *primary reticulum* of spicules, extending in all directions, whose interspaces are filled with unossified ground-substance,

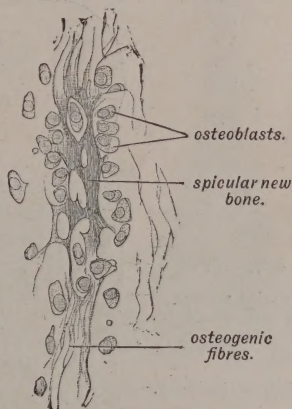


Fig. 69.—Ossification in embryonic tissue.

containing looped blood-vessels and many osteoblasts. Irregular layers of new bone, in which the osteoblasts are included, form on the spicules of this reticulum, and so the developing bone becomes lamellar, and by the multiplication of concentric plates the interspaces between the primary spicules become narrowed into cancelli, or Haversian canals. The branched and quickly-proliferating cells close to the blood-vessels become modified into red marrow.

The formation of bone commences and extends from definite spots in the tissue, which are called **centres of ossification**, so that a section through a very young bone shows the various stages in progress—laminated bone centrally, spicular bone peripherally, the ends of the spicules showing the projecting stiff bundles of the fibres extending into the, as yet unossified, ground-substance. The spaces occupied by the osteoblasts become lacunæ, and unossified lymph paths in the ground-substance become canaliculi.

In the history of vertebrate animals, this is the primitive method of bone-formation, and as the earliest bones were scale-like ossifications in the dermis, so all bones thus formed are called **dermal** or **membrane bones**. The roof bones of the skull and the bones of the face are examples of membrane bones.

The *second method* of bone-formation is **chondrostosis** or ossification in cartilage. This may be *metaplastic*, the cartilage being converted into bone by the deposition of bone-earth in its ground-substance, and the entry therinto of blood-vessels. This is of very rare occurrence, only seen in man in the rudimental supercapula and surface of the scapular spine, and in a small part of the lower jaw. In all other parts of the skeleton the process is *neoplastic*, and consists in the replacement of pre-existing cartilage by bone. The meso-blastic tissue in which the future bone is to be formed becomes converted

at first into parenchymatous cartilage, and subsequently becomes hyaline, and this is replaced by bone in either of two ways, which are called respectively **ectochondral** and **entochondral** ossification. In the former process, seen in the ossification of the shafts of long bones, at one spot in the cartilaginous forecast of the bone, the tissue increases in density, the cells enlarge and become arranged in columns which are regular near the centre of transformation, but become irregular where they merge into the, as yet unaltered, cartilage. The ground-substance increases between the columns of cells, and calcareous matter becomes deposited in it, producing a reticular calcified

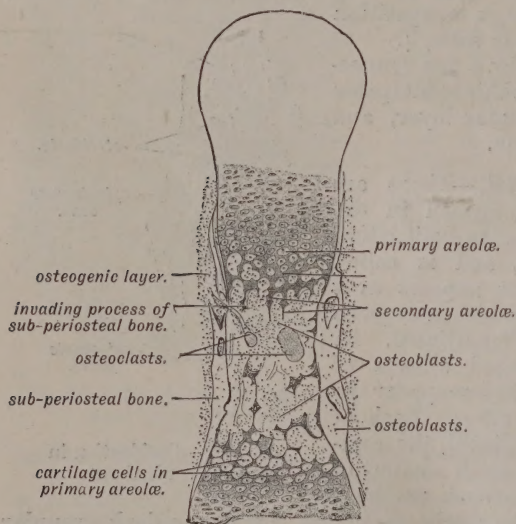


Fig. 70.—Ossification in cartilage.

cartilage, in whose meshes or *primary areolæ* are the piles of cells, each surrounded by a small quantity of calcified ground-substance.

While these changes are in progress, the enveloping perichondrium thickens and increases in vascularity. The cells in its deep layers give origin by proliferation to many osteoblasts, surrounded by a homogeneous ground-substance, in which parostotic ossification begins; so the calcified cartilage becomes

surrounded by an envelope of membrane bone, which rapidly grows in thickness. From the vessels of this layer invading loops press inwards, causing absorption of the calcified cartilage before them, and so burrowing into the meshes of the cartilage in which the columns of cells were imprisoned. The spaces thus opened (*secondary areolæ*), are larger than the original meshes, from which they differ in containing blood-vessels. Most, if not all, of the cartilage cells become shrivelled, and the areolæ become filled with a homogeneous ground-substance, interjected by irruption from the subperiosteal tissue along with the blood-vessels, in which osteoblasts are contained and osteogenic fibres form. Large polynuclear masses of protoplasm become adherent at spots to the walls of the areolæ, and beneath these, erosion of the calcified cartilage proceeds so actively that the cells have been called **osteoclasts**. On the walls of the areolæ, layers of new bone form in the same manner as they are formed on the primary reticulum of membrane bone, the numerous osteoblasts included therein sharply marking out this new bone from the shreds of the rapidly disappearing calcified cartilage, which have no lacunæ, and which appear dark and granular beside the clear and transparent new bone. This new bone is at first reticular, but subsequently becomes lamellar, the hollows becoming cancelli or canals.

By the time that the calcified cartilage has become supplanted by the new osseous tissue, the whole bone appears as a cancellated mass. As the densest of the successive laminae form both subperiosteally and around the vessels directly connected with the periosteum, so the bone changes in character as growth proceeds; its surface becomes denser and more laminated, and the spicular bone becomes either surrounded or replaced by the regular lamellæ of the Haversian systems. This change makes rapid progress between the period of birth and the end of the first year, but the shafts of the long bones have not quite lost their embryonic character before the end of the fourth year.

Coincidentally with the formation of these external laminae, and the consequent condensation of the circumference, absorption progresses in the central portion, thus eventually producing the hollowing of the medullary canal.

Before ossification, the pre-existent cartilage grows rapidly in all directions, and each segment of the primary skeleton of a limb appears of nearly equal thickness throughout, until it is restrained by the limiting ferule of subperiosteal bone. This ring first appears near the middle of the shaft, and from thence progresses towards the ends; so the terminal cartilage has time to widen towards the articular ends. The constraining ferule ceases where the periosteum ceases to be attached, at the border of the articular surface; hence, growth of the cartilage proceeds unimpeded in the articular end, and there is generally a constriction or **anatomical neck** around the margin where the periosteum ceases, due to the covering of the ending of the ferule by an overgrowth of the cartilage. Opposite this line the advancing vessels of the areolæ form a network of looped capillaries, which provides abundant nutrition for this region. The dilatation of the articular ends due to this expansion of

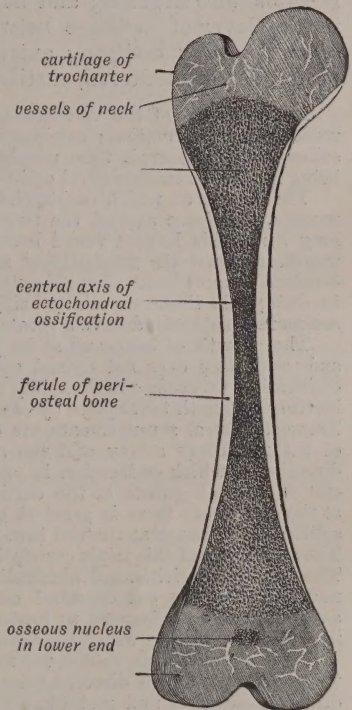


Fig. 71.—Section of femur of infant two weeks old.

the cartilage is to some extent compensated by the subsequent thickening of the subperiosteal bone of the shaft.

The articular ends of long bones ossify separately from the shafts, and, as in short bones, their ossification is entochondral, there being no investing layer of subperiosteal bone; but otherwise the process differs little from ectochondral ossification. It begins by the shooting in of a cluster of vessels from one region of the periphery into a central spot of the cartilage. These form a close meshed network, while the surrounding cartilage cells become ranged in columns, around which the ground-substance calcifies, and forms meshes into which osteoblast-holding tissue grows from without, breaking up the meshes and forming secondary areolæ whose walls thicken like those of the areolæ in the shaft. This process goes on unchecked as long as any cartilage remains unconverted; and at the ends of long bones in young persons, it is in the layer of cartilage between the ectochondrally ossifying shaft, and the entochondrally ossifying extremity, that growth takes place by the increase of the, as yet unaltered, cartilage.

In the history of the vertebrata, metaplastic ossification of embryonic tissue is the oldest mode of bone-formation; calcification, and afterwards metaplastic ossification of cartilage, subsequently appeared, then neoplastic ectochondral ossification—the latest form to appear being neoplastic entochondral ossification.

The centres at which ossification begins are the spots at which nutrition is most active, namely, the tissue around the largest vessels which enter the bone. In the shaft of each long bone, this largest vessel becomes the artery of the central medullary canal, and is therefore called the **medullary artery**. The position and number of ossific centres is constant in most bones; but all centres are not of equal morphological value—those occurring in embryonic tissue especially being easily modified or multiplied, while those in cartilage are more constant and have a greater historical importance.

The growth of bone and of its pre-existent cartilage are not necessarily commensurate, and ossification does not extend equally in all directions from these centres. In each bone ossification proceeds more rapidly in one direction than in the other, and in consequence increase of length takes place by continuous growth of the cartilage at the opposite extremity. Three structural arrangements are consequently correlated in each bone—(1) the obliquity of the medullary artery and the majority of the superficial arteries, which point in the direction in which ossification is progressing most rapidly, and consequently away from the end of greatest growth of the cartilage; (2) the epiphysis of earlier ossification is usually at the end where there is greatest growth of the cartilage; (3) the epiphysis of earlier consolidation is always at the end towards which shaft-ossification is progressing most rapidly. The advantage of this triple correlation is easily understood on the theory of natural selection. The limit of perichondral ossification, due to the formation of articular ends, creates the necessity for the entochondral ossification of the epiphyses; the epiphyses being thus supplemental contrivances to hasten solidification, and they appear first in the end which is opposite to that in which ossification is most rapidly progressing.

In the femur, ulna, radius, the metacarpals of the thumb and great toe, and the phalanges, the nutrient artery is directed towards the proximal end. In the humerus, tibia, and the other metacarpals and metatarsals it runs distally. In the bones of hand and foot, bony growth extends so rapidly in the direction of earlier ossification, that no cartilage is left wherein to form an epiphysis. These bones, therefore, have only an epiphysis at the extremity of the most rapid growth. In the fibula the lower end is that of most rapid growth, and the upper is constrained owing to its subservience to the tibia, hence its lower epiphysis is both earlier in ossification and in consolidation than the upper, which is a degenerate end.

Mechanical environing conditions are the chief factors which determine and modify the growth of bones. Along the lines of pressure, bones become thickened and denser; along lines of tension, they become elongated and projected. With unilateral pressure, they become curved; with oblique and terminal pressure, twisted. These characters are hereditarily impressed upon bones, and we can even trace the outcome of ancestral experience in the directions in which the primary spicules are formed. The details of configuration of the adult skeleton are so directly moulded by habitual posture and the action of muscles, that there are fewer rudimental organs in it than elsewhere in the organism.

The mode of growth of bone is threefold—(1) in length, by the proliferation of the cartilage at each end of the bone, especially the portion between the shaft and epiphysis. This mode of growth has been ascertained by experi-

ment, and it has been shown that the growth at the end towards which the nutrient artery points, is less than that at the other end. (2) In thickness, by the formation of subperiosteal lamellæ. (3) Interstitial growth also takes place, as bone tissue undergoes metabolism like other living materials, old Haversian systems becoming absorbed and new ones forming. On this account the curves of bones may alter during life, if the amount and direction of the forces to which they are exposed alter.

The rates of growth vary in the different bones, but the individual variations are so great that no general rates can be formulated.

28. THE SURFACES OF BONES present for study—(1) **articular extremities** whose shapes depend on the direction and amount of the movements in the joints which they form; (2) **surfaces**, sculptured in relief by their relation to soft parts, here and there raised into round blunt bosses (**eminences**), or obtuse knobs (**tuberosities**), or sharper points (**spines**), or lines, or crests, or other irregularities which are known by the generic name of **processes**. In other places bones are depressed into **fossæ** or **sulci**, which are either real hollows made by the pressure of some contiguous part, or apparent grooves left by the elevation above the original surface of two marginal ridges. Perforations in bones may be either for the transmission of vessels or nerves, or else spaces of deficient ossification.

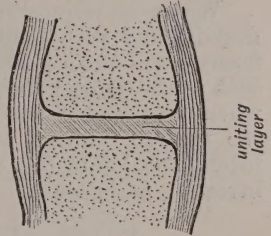
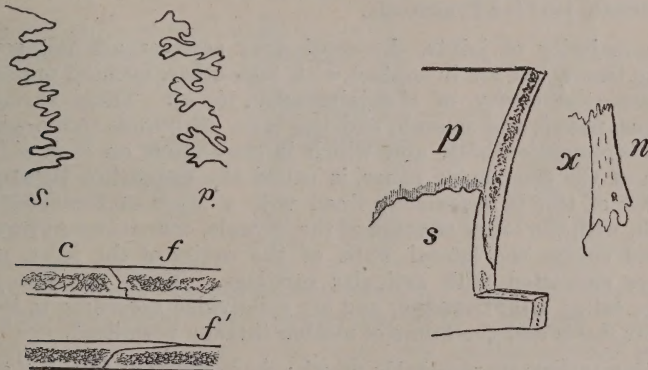


Fig. 72.—Synarthrosis.

29. JOINTS.—The place where two bones come in contact with each other is called a joint or articulation, in the simplest form of which the contiguous ends are fastened together by an intervening mass of connective tissue. Joints of this class are called **Synarthroses** (fig. 72), and they differ among themselves according to the nature of the uniting medium, the shapes of the opposed surfaces, and the widths of the intervals between the bones. The immovable articulation of the contiguous margins of flat bones with a minimum of inter-



Figs. 73 and 74.—Sutures.

vening tissue is a **suture** (figs. 73 and 74), which, if the edges be even and evenly applied, is *harmonic* (fig. 74, *x*), as illustrated by the joints around the nasal bone (*n*); if one margin overlap the other, it is a *squamous suture*; if the edges be toothed, and interlock, with teeth tapering to points, it is *serrate*; if they dovetail, it is *dentate*; should the interlocking edges alternately overlap, it is a *limbous suture*.

The temporo-parietal joint (fig. 74, between the parietal, *p*, and the temporal, *s*) is an example of a squamous suture; the inter-parietal (fig. 73, *s*.) of a serrate; the occipito-parietal (fig. 73, *p*.) of a dentate; and the fronto-parietal of a limbous suture, as the frontal (*f*) overlaps the parietal (*c*) above, while the parietal overlaps the frontal (*f'*) below.

When a ridge of one bone is received into a groove in another, the joint is called **Schindylesis**, as in the union of the vomer with the sphenoid; and if a peg of one bone be received into a mortice in another, as the teeth in their sockets, the joint is called **Gomphosis**.

When the interval between the bones is wider, so that the uniting connective tissue is elongated into ligamentous bands, the joint is named **Syndesmosis**; and if the ligament be flattened into a thin expansion, it is called an *interosseous membrane*.

When the connecting substance is cartilage, the joint is named **Synchondrosis**, and such joints may be of two kinds; *true*, when they arise by the formation of two separate and approaching ossifications in a continuous cartilage, such as the joint between each epiphysis and shaft in a long bone; or *false*, when the tissue is fibro-cartilage, not hyaline, formed by the chondrification of the medium uniting two originally separate bones, as in the sacro-iliac or inter-pubic joints (fig. 75). None of the bony surfaces of these joints have an investing periosteum.

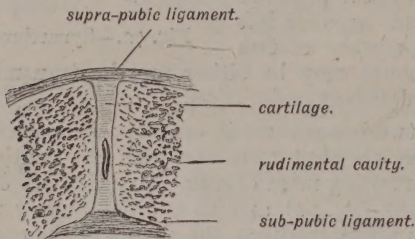


Fig. 75.—Symphysis pubis in vertical section.

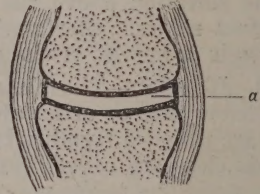


Fig. 76.—Diarthrosis.

Synarthrodial joints may become obliterated by the ossification of the uniting medium; such an obliterated joint is a **Synostosis**.

In the majority of joints, the contiguous surfaces are not separated by intervening tissue, but are in contact with each other, forming opposite sides of a free space (the cavity of the joint—fig. 76, *a*). These surfaces remain cartilaginous, naked, and smooth, and the layer of fibrous tissue which invests the cavity circumferentially, and which is continuous on each side with the periosteum of the component bones, is called the **capsular ligament**. The inner surface of this is imperfectly lined with a layer of flattened endothelial cells, which, with the inner stratum of the capsule, constitutes **synovial membrane**, and covers the lateral walls of the cavity of the joint, except such parts as are encrusted with articular cartilage. These movable joints with a cavity are called **Diarthroses**, and are subdivided according to the shapes of the articular facets and the kinds of motion thereby permitted.

The cartilage surfaces are remarkably smooth; the coefficient of friction of cartilage upon cartilage when moistened by synovia being exceedingly small. Synovial fluid is an exudation containing mucus, formed on the surface of the villi and folds which fringe the margins of reflection of synovial membranes. The size of the cavity of each joint is invariable, and is correlated with the extent of its mobility. When this is large, the synovial membrane is pouched, or extends over a portion of bone on each side of the cartilage. When small, the synovial membrane is of small extent.

In some very movable joints, such as the hip and elbow, when in certain positions a larger, and in others a lesser, bulk of one bone is received into a cavity in the other, masses of fat are disposed outside the synovial membrane and inside the capsular ligament; so that in the

latter case they are made to bulge into the joint by the tension of the overlying ligament, while in the former they are pushed out into extra-articular recesses. Such masses of fat are called **Haversian glands**.

The strength of the capsule varies with the shape of the articular surface, is proportional directly to the strain it has to bear, and inversely to the size and strength of the muscles and tendons which surround it. It is weak under strong tendons; but in the intervals between muscles it is strengthened by the adhesion to its outer surface of fibrous bands derived from intermuscular septa of fascia (fig. 77, at *r*, *p*, and *f*), from modified tendons, or even from degraded muscles. These structures are called **accessory ligaments**, and they are chiefly of use in restraining excessive degrees of motion in unnecessary or injurious directions. The muscles around each joint are the chief uniting and supporting agents; the ligaments supplement them in these respects, and serve to regulate and limit the amount of motion.

Menisci.—In some joints a free lip of fibro-cartilage (fig. 78) projects into the articular space between the bones. These meniscus-cartilages are thick, and attached to the capsule at their circumferential edge; but are thin at their inner, free margins. When a plane of fibro-cartilage extends completely across the joint space, dividing it into two separate cavities (*c.s* and *c.i*), it is called an **inter-articular cartilage** (fig. 78, B, *i*); such cartilages exist in the sterno-clavicular, temporo-mandibular, and ulno-carpal joints. When a meniscus is immovably attached to the margin of one bone, and so deepens the socket, it is a **cotyloid ligament**, as in the shoulder- and hip-joints (fig. 79).

Diarthrodial joints develop early, and in order of size; they are all distinct by the tenth week. The thickness of the encrusting cartilage in an adult joint is proportional to the amount of pressure and to the size of the articulation.

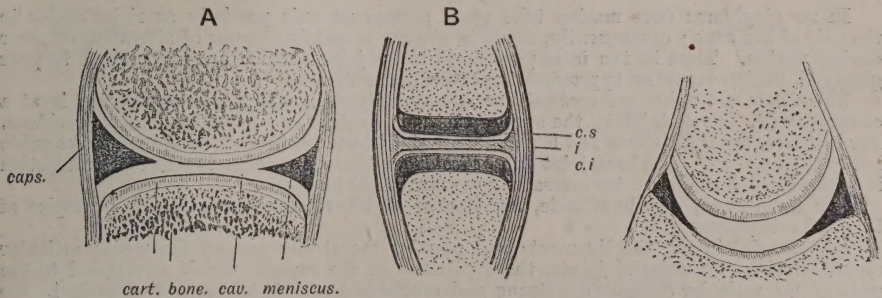


Fig. 78, A, Meniscus; B, Inter-articular cartilage. Fig. 79.—Cotyloid ligament.

30. CLASSIFICATION OF DIARTHRODIAL JOINTS.—Diarthrodial joints are (A) **Homomorphic**, with equal and similar opposed surfaces, or (B) **Heteromorphic**, with dissimilar surfaces. Homomorphic joints are either (1) **plane**, with flat surfaces admitting of little motion, such as most of the intercarpal and intertarsal joints and those of the articular processes of the cervical and dorsal vertebrae; or (2) **ephippial**, biaxial joints, as the trapezio-metacarpal (fig. 80), with saddle-shaped surfaces, concave along one axis, convex along the other.

Heteromorphic joints are divided into the following series:—(1) **Enarthrodial** or ball-and-socket joints are those in which one articular surface forms

a socket into which the other, which is the segment of a spheroid, is received. The distal bone is capable of motion around an indefinite number of axes which intersect each other in one point, the *centre of rotation*.

The motions may be considered as taking place around axes in the three ordinal planes. Motion around a transverse axis in which the distal end of the remoter bone is drawn towards the proximal end of the upper bone, is called *flexion*, motion in the opposite direction is *extension*, motion around a sagittal axis from the middle line is *abduction*, towards the middle line is *adduction*. The turning of a bone on its vertical axis is *rotation*, while the name *circumduction* is given to the compound of successive flexion, adduction, extension and abduction, wherein the bone revolves on the surface of an imaginary conoid, whose apex is the centre of rotation, and whose base is the closed curve (never a circle) described by the distal end of the limb. In the shoulder and hip, the ball moves in the socket; but in the metacarpophalangeal and humero-radial, the socket moves on the fixed ball.

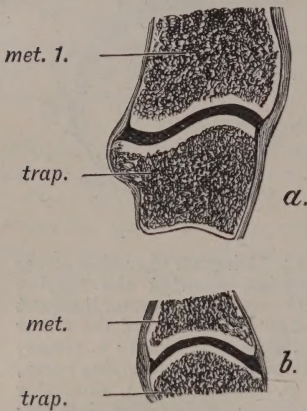


Fig. 80.—Trapezio-metacarpal joint—*a*, coronal section; *b*, sagittal section.

(2) **Condylarthrosis.**—When the convex articular head is ellipsoidal in outline, with a socket of corresponding shape, as in the metatarso-phalangeal joints, rotation is restricted or impossible, and the joint becomes practically biaxial. A head of this shape is called a **condyle**.

Most condylarthrodial joints are laterally double, and so motion cannot take place around a sagittal axis. The atlanto-occipital and temporo-mandibular joints are examples.

(3) **Hinge Joints.**—When two such condyles are confluent, as in the knee, or when the convex articular surface is the segment of a cone or a cylindroid, rotating in a corresponding cavity, the restriction of motion to one plane is more complete. In such joints the long axis of the cylinder is either transverse or vertical; the former are called **ginglymus** joints, the latter **trochoid**.

In no ginglymus does motion take place around an axis precisely at right angles to the axis of the bone; consequently, there is always a certain amount of alteration of plane during flexion. Thus in the inter-phalangeal finger-joints, which are the nearest to pure ginglymi, flexion causes an approximation of the finger tips.

The elbow and ankle are *cochleoid* or *screw ginglymi*, in which this translation is at a constant angle. In such joints, the axes of those of the right and left side are not coincident. For instance, the right elbow and left ankle are right-handed, the left elbow and right ankle left-handed screws. The knee-joint is a *helicoid ginglymus*, in which the line of translation is a spiral whose radius vector increases downwards and forwards.

The radio-ulnar, odonto-atlantic, and lumbar vertebral articular joints are examples of trochoid articulations.

In polyaxial joints, the ligaments and muscles are strong around the whole articular circumference. In uniaxial joints, those portions of the capsule which correspond to the ends of the articular cylinder are strong and specialised as *lateral ligaments*; while in the plane of motion at right angles the ligament is weak, though the muscles are strong. No diarthrodial joint in man has its surfaces so arranged as to remain locked when the soft parts are removed, like the shackle joints of some lower vertebrates: nor is the range of motion permitted by the soft parts so great as to allow of the jarring of the non-articular parts of the bones one on another.

Historical Classification.—Joints are either primary or secondary, the former commencing as clefts in a primitively continuous mesoblast (fig. 82, *cl*), the latter being subsequently formed by the approximation, in the course of growth, of parts originally separate. The intervertebral and intermetacarpal articulations are examples of secondary joints.

In polyaxial joints the convex surface is generally the more movable, in uniaxial the concave, except in the cases of the ankle and wrist.

Joints not only permit of motion, but of interstitial growth. This is especially the purpose subserved by synarthroses.

31. STATICAL AND DYNAMICAL RELATIONS OF BONES.—The bones act as levers, the three orders of which are exemplified in the body. The forearm is a lever of the *first order* (fig. 81) when being extended by the triceps (*tr*); having the *power* (*p*) at the olecranon, the *fulcrum* (*f*) at the elbow, and the *weight* (*w*) at the hand. As the elongation of *p*, *f*, is limited, levers of this kind act at a disadvantage, and consequently the majority of the levers in the skeleton are one-armed and mostly of the third order, with the power (*p'*) between the fulcrum and weight. The forearm flexed by the biceps (*bi*) is an example, having the power applied at the insertion of the muscle, between the weight at the hand and the fulcrum at the elbow.

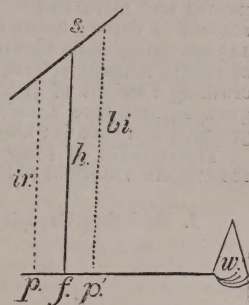


Fig. 81.—The arm bones as levers—*s*, scapula; *h*, humerus.

In such a lever, the power can seldom be applied in the direction of greatest effect—i.e., at right angles to the lever, so the useful force is $f \sin \phi$.

The foot acts as a lever of the *second order*, when acted on by the calf-muscles in raising the heel and throwing the weight of the body on the toes. Here the weight is intermediate between the power at the heel and the fulcrum at the balls of the toes.

Physical Properties.—The following tables exhibit the most important physical properties of bone as compared with other hard substances.

I. *Weight in kilos*, required to crush a rod of the following materials, 1 square millimetre in cross-section:—

Steel,	145	Bone,	15	Oak,	4.8
Cast iron,	73	Granite,	5.9	Pine,	2.9
Wrought iron,	22	Lead,	5	Fire-brick,	0.9

II. *Breaking limit*, in terms of the weight in kilos, required to tear across a rod 1 square millimetre in cross-section:—

Steel,	102	Oak,	6.5
Wrought iron,	41	Zinc,	5
Cast iron,	13	Granite,	1.9
Bone,	12		

III. *Specific gravities* of these materials:—

Lead,	11.352	Zinc,	6.8
Wrought iron,	7.788	Granite,	2.130
Cast iron,	7.207	Bone,	1.87
Steel,	7	Oak,	0.845

IV. *Modulus of elasticity** of these materials:—

Steel,	22,000	Lead,	1,800
Wrought iron,	19,000	Oak, parallel to grain,	1,100
Bone, humerus,	3,400	Oak across grain,	130
„ femur,	2,264		

Owing to the varying amounts of ground-substance and fibrous matter, these qualities vary to some extent in different bones; the humerus being the hardest and least tenacious, the tibia the most tenacious of all the limb bones.

The rough experiment of placing a clavicle upright with one end on a table and striking the other smartly with a hammer, illustrates by the distance of rebound the elasticity of bone. A section of the shaft of the femur, 3 cm. long, bore, on being tested, a weight of 1,200 kilos. without giving way.

The bony skeleton of an adult man weighs, when fresh, about 9 kilos.; when cleaned and

* The modulus of elasticity is the reciprocal of the fraction representing the proportional amount, by which a rod of the substance 1 square mm. in section is lengthened by the load of 1 kilo.

dry, 5'33 kilos.; it makes '143 of his weight; that of the female '132; that of the child at birth weighs 95 grammes, and is '03 of the entire weight.

In old age, when tissue-nutrition is impaired and movements are slow, the bones become porous and more fragile, not from alteration in composition, but from diminution in the amount of tissue; hence they become lighter. The femur of a woman of 103 years weighed 145 grammes, while that of a woman of 40, of the same size, weighed 350 grammes. A cube of recent cancellous bone, 1 square cm. of surface, weighed 1'1 gramme, and bore without crushing a weight of 41 kilos. A cube the same size of dry cancellous bone weighed 0'6 gramme, and bore a weight of 36 kilos. A similar cube of compact bone weighed 1'8 gramme, and bore 613 kilos.

The shafts of long bones are hollow columns; thereby material is economised with the minimum sacrifice of strength, as shown by the following tables:—

I. Resisting Capacity of Columns constructed of the same Amount of Material.

	Diameter.	Crushing Limit.	Snapping Limit.
Solid column,	100	1,000	10
Hollow column,	125	2,125	17

II. Resisting Capacity of Columns with the same External Diameter and varying Amounts of Material.

	External Diameter.	Diameter of Central Cavity.	Proportional Weight of Material.	Crushing Limit.	Snapping Limit.
Solid column,	100	0	1	1,000	8
Hollow column,	100	60	0'6	870	7
Hollow column,	100	80	0'34	599	4'8

In the skull, wherever thickness and a wide surface are required, lightness is secured by the development of air cells, as in the frontal, ethmoid, sphenoid, maxillary, and temporal bones.

32. THE APPENDICULAR SKELETON.—We have seen that the limbs arise as lateral mesoblastic projections on the outer side of the muscle-plates.

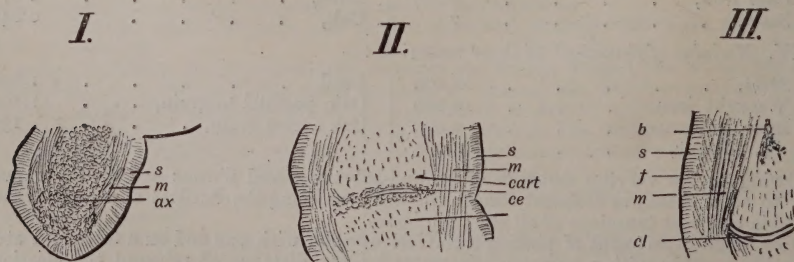


Fig. 82.—Section of embryonic forelimbs—I., earliest stage; II., chondrifying stage; III., ossifying stage.

As growth advances, the embryonic tissue differentiates, the central axis of each (fig. 82, *ax*) becoming distinct from its envelope of muscular (*m*) and connective tissue (*s, f*). The proximal portion of the axis is flattened and embedded in

the somatopleure, forming the *limb-girdle*; the distal part is central, in the limb-ray. In each of these, chondrification begins at a series of distinct centres (*cart.*), and clefts form in the tissue between the separately chondrifying areas, becoming a series of primary joints (*cl.*).

The limb-girdle divides into two parts, one on the dorsal side of the point of attachment of the limb-ray, and one on the ventral side, extending in the somatopleure towards the medio-ventral line.

The cartilage of the limb-ray becomes subdivided into a series of successive segments; a single *basipterygial* articulates above with the girdle and below with two secondary elements in the second segment. Below these are two rows of irregular elements (called *carpals* in the upper, *tarsals* in the lower limb), succeeded in turn by a series of five *metacarpal* or *metatarsal* elements, each bearing distally a digit of two or three successive segments (*phalanges*).

The fore and hind limbs have originated from correlative parts of successive segments, and have been subjected to similar but not identical influences in their development; hence there is a certain degree of correspondence or *serial homology* between their component parts. But, as in the later periods of development the conditions of the two limbs have been dissimilar, most of the adaptive characters are peculiar to each limb. The primary vertebrate limb was probably an organ of swimming, which became subsequently one of progression. The power of prehension is a late acquisition, hence the characters of the lower limb are more archaic than those of the upper. The serial homologies of the segments of the limbs will be noted in connection with their descriptive anatomy.

33. SEROUS MEMBRANES.—The connective tissue that fills interstices between parts which move upon each other becomes laminated, and is composed of a loose-meshed texture of white and yellow fibres, with flattened connective cells on its surface. A like covering of endothelial cells invests every cord-like tendon. When this tissue is so arranged that its layers glide upon each other, the fibrillar basis becomes condensed and membranous, and the contiguous surfaces are overlaid by endothelial cells. When, at an early period of embryonic life, the mesoblast splits to form a cœlom, the lining tissue of this cavity (fig. 11) undergoes a transformation of this nature, and to the layer thus formed the name *serous membrane* is given. This primitive

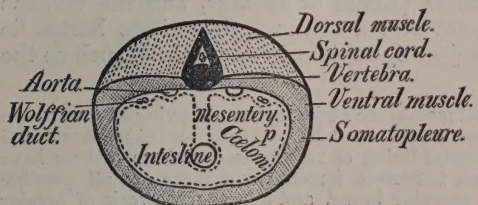


Fig. 83.—Diagram of section of embryo showing cœlom, and its lining serous membrane represented as a dotted line.

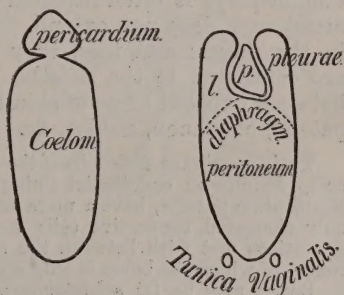


Fig. 84.—Partition of the cœlom.

serous membrane (fig. 83) consists of two portions, a parietal layer (*p*) lining the inside of the somatopleure, and a visceral layer, the mesentery, covering the outside of the splanchnopleure; and as these walls are continuous with each other at the base, so in any plane of section the serous membrane appears as a continuous line returning on itself. As the splanchnopleure becomes complex by its increase in length and by the formation of outgrowths, so the visceral layer of the serous membrane becomes commensurately complicated. The subsequent formation of partitions shuts off its extreme parts as independent serous cavities (fig. 84); thus, the part investing the heart forms the *pericardium* (*p*), which becomes displaced downwards in the course of development;

the growth of the diaphragm separates the pouches on each side of this as the right and left *pleuræ* (*l*); and the sacs around the testes become the *tunicæ vaginales*. The remaining portion lining the abdominal cavity is the *peritoneum*.

The space enclosed by a serous membrane is really a great areole or lymph space, a gigantic exaggeration of those interstitial lymph paths which surround the cells in areolar tissue. The closeness of its wall-coating of endothelial cells prevents the undue leakage of fluid, but the cells become especially modified around certain stomata or persistent inter-spaces. In this sense, a serous membrane has many openings into it; but macroscopically it appears as a shut sac, the only place where a large perforation exists in a serous membrane being in the peritoneum of the female, at the extremity of the Fallopian tube. The viscera lie outside the serous membranes, and hence there is a double lamella at the base of each organ (Fig. 83, *mesentery*).

The endothelium of serous membrane consists of one layer of large flat cells, with irregular margins and thick bulging nuclei. The underlying connective layer varies in strength, but is rich in lymph spaces and vessels. Inside the head there is a layer of membrane (the *arachnoid*) investing the brain and resembling a serous membrane, but with no definite parietal layer, although the endothelium of the fibrous lining of the head (*dura mater*) is continuous with that of the arachnoid.

Serous membranes act as large lymph spaces; they serve to diminish friction during the motions of the viscera, which they retain in their places.

34. SYNOVIAL MEMBRANES resemble serous, but are later in date of origin, and their surfaces are, here and there, projected into villi, whose superficial cells secrete a muco-albuminous fluid in place of the serous exudation which moistens true serous membranes. Synovial membranes lining joints are not of themselves shut sacs, as there is no membrane covering the cartilage, nor on some patches of the circumference where the ligaments are strongest. The deep layer of synovial membrane is more vascular than that of serous.

Synovial membranes are found either as the lining of joints, or as *bursæ*, which are closed sacs (*a*) between contiguous soft parts, or (*b*) beneath soft parts which glide tensely over a bone. Bursæ are formed around and beneath tendons in the neighbourhood of joints; and the hard part on which the tendon plays is often invested with a layer of cartilage over which the synovial membrane does not extend. When they completely surround tendons, as in the fingers and toes, they are called *thecæ* or sheaths, and the tendons are connected to the sheaths by synovial reflections. Sometimes bursæ lie between exposed areas of skin and projecting subjacent bony points, such as the patella, olecranon, ankles, &c.

Their membrane differs from the synovial membrane of joints in not having so continuous or so definite an endothelial lining; indeed, while some bursæ, such as that beneath the ligamentum patellæ, have a more or less regular lining of regular endothelium, others have only elongated connective cells forming an imperfect lamella; and there are all possible gradations met with between the regular saccular bursa, and a loose meshwork of areolar tissue, of which the bursa is only a specialisation.

Bursæ may be (1) *subcutaneous*, (2) *subfascial*, (3) *between two tendons*, or (4) *between tendons and subjacent ligaments or bone*. Of these, some communicate with the neighbouring joints always, some occasionally, and some never.

Bursæ underlying parts which have an extensive range of motion are *unilocular*, with a single cavity. Bursæ spread over an extensive surface, and whose walls move but little on each other, are often divided by imperfect fibrous septa, and are called *multilocular*. Almost all the deeper bursæ are unilocular, most of the subcutaneous bursæ are multilocular.

NERVOUS TISSUES AND THE NERVOUS SYSTEM.

§ 35. NATURE OF NERVOUS TISSUE.—All protoplasm is capable of being stimulated to metabolism and the discharge of energy by external agencies; but in the differentiation which characterises the development of animals, a physiological division of labour takes place in many cells, whereby the contractility of one part of the apparatus becomes intensified, constituting muscular tissue, while the capacity of receiving sensations becomes concentrated in other cells of the surface layer. In vegetables, the continuity of protoplasm in contiguous cells is the method whereby the organism is unified; but in animals, where this continuity fails, a supplemental contrivance is needed for the purpose. In the lower metazoa this differentiation is partial, sensation being possessed by most of the ectodermal cells, whose bases are elongated into long contractile processes, on which account they are called neuromuscular cells. In animals of a higher grade, the capacity of receiving and transmitting impressions becomes limited to the cells of a certain part of the surface only, and these, which are called *nerve cells*, become differentiated from the cells of the muscular system, although correlative to them in function. In such animals the nerve cells receive the impress of a stimulus from without, and transform it into an impulse of nerve force, which sets up contraction in the muscle connected therewith; and, in the natural living state, muscle only contracts when it receives its stimulus through its nerves. In higher animals, the development of the nerve cells chiefly takes place in an elongated strip of epiblast



Fig. 85.—Nerve cell from Gasserian ganglion—*n*, nuclei of sheath; fibre dividing at *t*, node of Ranvier.

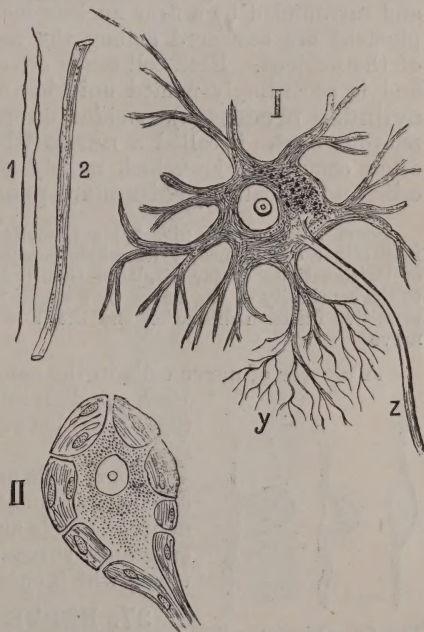


Fig. 86.—I, Nerve cell from anterior horn of spinal cord; II, ganglion cell and sheath.

in the mediodorsal line; and in the in-folding of the organism during its embryonic growth, these cells constitute the functional portion of the tissue which is included between the medullary folds, and which consequently forms a large element in the wall of a closed tube, the *primitive central nervous system* (fig. 13).

The two tissues, nerve and muscle, in which these animal properties of irritability and contractility inhere, are called "animal" tissues, to distinguish them from epithelium and connective or "vegetative" tissues.

The tubular wall of the primitive central nervous system consists at first of a single layer of cells, but these multiply and differentiate, some of the cells becoming elongated, and uniting with their fellows to form a reticulum of support-cells (**neuroglia**), whose interspaces are filled by the true nerve cells and their processes. The nerve cells themselves become divided into a *receptive* series, which receive impressions from without, and a *distributive* series, in which the impulse is transformed into a wave of nerve force to be transmitted to the muscles.

In the human body, the component tissues of the nervous system are usually divided into nerve cells and nerve fibres; but the latter are only elongated processes of the former, from which they cannot be morphologically separated. The axis cylinder is no mere telegraph wire; it is a genuine extension of the central apparatus. For convenience of description, the nervous system may be divided into two parts, the *nervous centres* (brain and spinal cord), which are contained within the neural canal, and the *peripheral nervous system*, consisting of nerve fibres emitted from the centres, distributed through the body, and ending in the different tissues.

36. NERVE CELLS.—Nerve cells are rounded, fusiform, or stellate, differing in shape in the several parts of the central nervous system, and varying in size from 60–135 μ in the spinal cord down to granules of extremely minute dimensions. Each cell has a wall containing a finely granular, obscurely fibrillated protoplasm, with a characteristic, large, round, clear, vesicular nucleus, containing a reticulum and one or two highly refracting nucleoli, and surrounded by a firm nuclear membrane. A few specks of greyish-brown pigment are scattered among the metaplastm granules, especially at the edge of the nucleus. Each cell sends off one, two, or more processes (fig. 86, I, *y*), and is accordingly named uni-, bi-, or multi-polar. One of these, the **axis-cylinder process** (*z*), remains unbranched, and its continuation out from the nervous centre is called a **nerve fibre**, while the others when they exist are often complexly branched, mostly anastomosing with those of neighbouring cells, and are called **protoplasm processes**, although they are non-contractile.

Some bipolar cells (fig. 87) are nucleated dilatations in the course of a fibre, which may either occupy nearly its whole continuity, or may be unilateral, bulging on one side of it, sometimes so far displaced that the cell appears as if it were unipolar and joined to the continuity of the nerve by a single neck; but gradations are traceable between the primitive fusiform dilatation and the T-shaped mode of union with the continuity of the nerve.

A cluster of nerve cells in the course of a nerve cord is called a **ganglion**.

Each ganglion cell is enclosed in an endothelium-like sheath (fig. 85, *n*); between this and the cell there is often a lymph space.

Nerve cells are supported in the nervous centres (1) by the interlacement of their protoplasm-processes, (2) by the neuroglia cells and a certain amount of a granular ground-substance surrounding them, and (3) by a little connective tissue which enters with the blood-vessels.

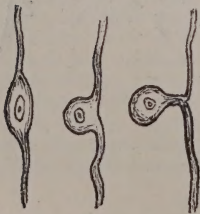


Fig. 87.—Bipolar cell becoming unipolar by approximation and union of poles.

37. NERVE FIBRES, which convey the impressions of external stimuli to the nerve cell, or impulses of nerve force from the cell to the muscle, consist, in their simplest form, of the far-reaching extension of the axis-cylinder processes of the nerve cell. Each of these is band-like or cylindrical, transparent, consisting of a semi-fluid material, enveloped in a very thin but resisting sheath of neuro-keratin, and, when acted on by reagents,

appears to consist of a variable number of fine homogeneous, often moniliform, primitive nerve fibrillæ, each of which measures from $\cdot 0005$ mm. upwards in diameter (fig. 86, 1 and 2).

The material around these fibrils in the axis cylinder appears as a faintly granular ground-substance, and the component strands frequently separate and reunite so as to form a minute network, ultimately separating for their final distribution into its component primitive fibrillæ. It is most probable that much of this fibrillar appearance is due to reagents.

Fibres of this kind are called *non-medullated* (fig. 86, 1 and 2), and are either

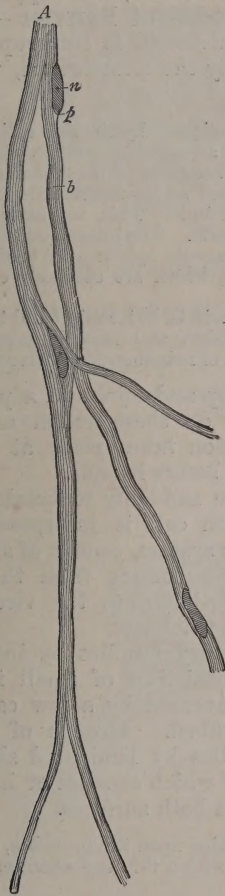


Fig. 88.—Remak's fibres non-medullated, with *b*, fibrils; *n*, nucleus and a little protoplasm, *p*, around the nucleus.

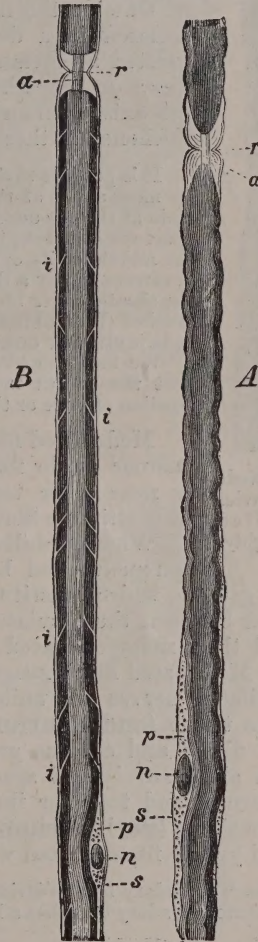


Fig. 89.—Medullated nerve fibres—*a*, axis cylinder; *s*, sheath of Schwann; *p*, granular substance at poles of nucleus.

naked, as in many sympathetic nerve fibres, or else are invested by a very faintly developed sheath or **neurilemma**, including a few elongated nuclei (fig. 88) embedded in the surface of the filament. Such fibres are found

in the olfactory and sympathetic nerves and all the nerves of the fetus before the fifth week.

In most human nerves the axis cylinder, after a short course, becomes invested with a glistening white highly refracting envelope, the **medullary sheath**, giving to the nerve when hardened a double-contoured appearance (fig. 89, *s*). Aggregations of these medullated fibres make up large portions of the nervous centres, the parts so constituted appearing white, while the masses of nerve cells appear grey from the pigment which they contain. We speak, therefore, of these as *grey* and *white* nerve matter respectively.



Fig. 90.—Node of Ranvier magnified more highly.

Outside the nervous centres, each medullated nerve fibre is enclosed in a delicate hyaline *neurilemma*, and appears constricted at certain definite spots (**nodes of Ranvier**—figs. 89, *r*, *r*; 90, *fs*) where the medullary sheath is interrupted, and the axis cylinder is covered only by the neurilemma, which is thickened at these spots.

It is possible that the absorption of nutriment by the axis cylinder may be most active at the nodes of Ranvier, as nerves placed in picocarmine stain at these nodes first. Each internodal segment of the medullary sheath possesses a nucleus (*n*) sunk into its surface under the neurilemma, about the middle of its extent, but not enclosed in it. This, in young subjects, is surrounded by a thin lamella of protoplasm. The internodal segments of the sheath under the influence of some reagents appear as if broken up by notches (**Lanternmann's**, *i*, *i*) into strips, which are obliquely cut at the ends (**cylinder cones**).

We know so little of nerve force that it is but conjectural to suppose that the sheath insulates the axis cylinder, and possibly prevents dissipation of force or the inductive influence of neighbouring currents.

Medullated fibres do not break up and rejoin in a plexiform manner as do non-medullated, nor do they branch except at or near their terminations. Division takes place at a node, each ultimate fibril losing its sheath before it ends.

When medullated nerves require suddenly to break up into non-medullated branches, a ganglion cell is interposed. The chains of ganglia, which constitute the sympathetic system, consist of such cells interposed between the insulated medullated fibres coming from the spinal cord, and their non-medullated continuations distributed to the viscera and vessels. Medullated fibres range from 1 to 20 μ in thickness.

Medullated nerves are united into small primary bundles by interstitial connective tissue (**endoneurium**—fig. 91, *ed*), consisting of small irregular cells, fine fibrils, and copious ground-substance traversed by a few capillaries and with abundant lymph spaces around each fibril. Groups of primary bundles are bound together into secondary bundles by laminated sheaths of connective tissue (**perineurium**, *pe*), each layer of which consists of interlaced white and yellow fibres coated with endothelium on both surfaces.

When each secondary bundle divides, the perineurium thins upon the branches, becoming on the ultimate secondary branches a homogeneous lamella with a thin endothelium (**sheath of Henle**).

Those cords, which in descriptive anatomy are called *nerves*, are formed by the aggregations of secondary bundles, invested by a connective **epineurium** (*ep*), which is connected by septa with the sheaths of the secondary bundles: a few blood-vessels, the fine *nervi nervorum*, and large, freely communicating lymph spaces are also contained in these sheaths.

Nerve tissue is dense, having a specific gravity of 1.036. The modulus of elasticity of nerve is 1.0905; and the breaking weight of a cord 8 sq. mm. in cross-section is 23 kilos. This

varies a little with individual nerves, and depends on the amount and arrangement of the connective sheaths. The sciatic nerve bore 46 kilos. without breaking, and the median 24. Twenty-seven cm. of the median nerve with this weight lengthened to 42 cm.

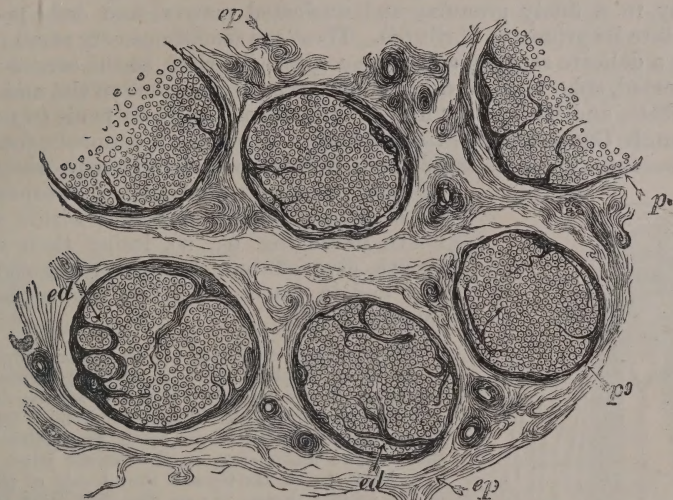


Fig. 91.—Transverse section of the intercosto-humeral nerve.

38. PHYSIOLOGICAL CLASSIFICATION AND ENDINGS OF NERVE FIBRES.—Nerves conveying impressions from the surface to the centres are called *afferent*, *sensory*, or *centripetal*; those which convey impulses from the centres to muscles are *motor*, *efferent*, or *centrifugal*. The former end superficially in or between epithelial cells; but we are still ignorant as to the

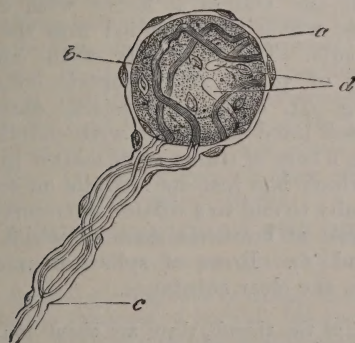


Fig. 92.—End bulb from conjunctiva—
b, core; c, fibre.

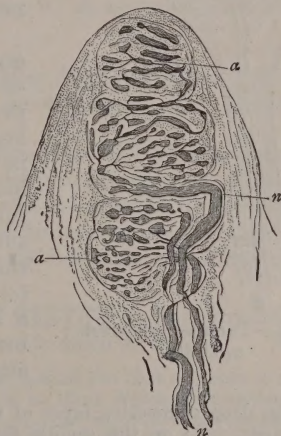


Fig. 93.—Touch corpuscle
from palm of hand.

molecular mechanism of nerve endings. The simplest nerve endings are fine free points between and in contact with simple or specially modified epithelial cells (cells of Langerhans—fig. 47, b), but more complex forms also occur of the following kinds:—

1. **Endbulbs.**—Rounded bodies at the ends of primary nerve bundles, composed of a capsule of connective tissue (fig. 92, *a*), continued from the sheath of Henle, and containing elongated nuclei; within this the nerve runs tortuously in a finely granular and nucleated matrix, and ends probably by dividing into its primitive fibrils (*d*). These are sometimes very small (·075 mm.) and with a delicate capsule, as on the conjunctiva close to the cornea; they are thicker-coated, spheroidal, and larger on the prolabium and on the under-tongue; larger, lobate, and with larger nerve filaments on the glans penis (·13 mm.)

2. **Touch Corpuscles.**—Larger bodies 0·13 mm. in diameter, found at the ends of secondary nerve bundles in dermal papillæ (fig. 93), enclosed in a nucleated and laminated connective capsule formed of the dilated sheath of Henle, within which the nerve fibres (fig. 93, *n*), losing their medullary sheath, give off branches nearly at right angles, and end in knobs, *a*, *a*, on the surface of the contained cells.

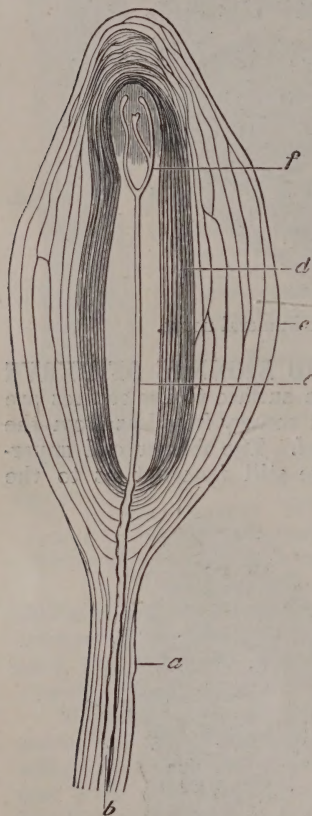


Fig. 94.—Pacinian corpuscle;
a, stalk.

Corpuscles of this kind are simple or compound, often in twins or triplets, straight or bent, ovate or lobed, according to the place in which they are developed; they are very plentiful on the skin of the hand. On the radial side of the last joint of the index finger there are 22 in each square millimetre; on the second joint, 8; on the first joint, 3; on the tip and thumb-side of the last joint of the middle finger, 17; on the first joint of the little finger, 1.

Corpuscles, which in character possess features somewhat intermediate between endbulbs and touch corpuscles, are found in the synovial folds of the finger-joints, as well as more sparsely in synovial folds elsewhere. In some tendons, there are thicker-layered corpuscles with unbranched nerves surrounded by rows of nuclei.

3. The largest of the nerve endings are **Pacinian corpuscles** (fig. 94), oval bodies 1·3 mm. long, each set on the end of a nerve with a thick perineurium, which is continued into the many layered capsule. The chief bulk of the corpuscle is made up of 30 or 40 concentric connective lamellæ (fig. 94, *c*) in two series, outer and inner (*d*), each lined internally with endothelium, surrounding a core of transparent matter in which the nerve which has lost its medulla on entrance (*e*) runs axially to end in a dilated extremity, or in a little umbel of branches, each of which has a knobbed end (*f*). Rows of spherical nuclei lie embedded in the clear substance.

In the deep connective layer of the dermis of the thumb, there are about 70; on the index finger, 105; on the middle finger, 60; in the whole hand, about 500. Others are scattered elsewhere; about 150 have been counted on nerves of the aortico-renal, celiac, and mesenteric plexuses. On the finger-joints they are numerous as also they are on the front of the elbow-joint; in all, 530 have been counted about the joints of the upper extremity, and 317 about those of the lower.

In *special sense organs* the nerve fibres end in the different kinds of neuro-epithelium, to be specially described in connection with each organ.

In *unstripped muscle* the non-medullated nerves form a primary or *ground*

plexus among the fibres, whose filaments unite into a secondary or *intermediary* plexus, whose nodal points are nucleated. This sends off *intermuscular* fibres (fig. 95, *d*), breaking up into primitive fibrils on the surface of the muscle cells. In striped muscles the medullated fibres run nearly at right angles with the muscle fibres, and the axis cylinders (fig. 96, *A*) pierce the sarcolemma, with which the sheath of the nerve fibre becomes continuous—the sheath of Henle (*b*) being continuous into the outer layer or epilemma which contains nuclei (*d*); Schwann's sheath into the inner or endolemma. The nerve then breaks up into a set of terminal branches, which are united by a granular intervening substance into an expanded plate, on a nucleated basis (*B*), lying

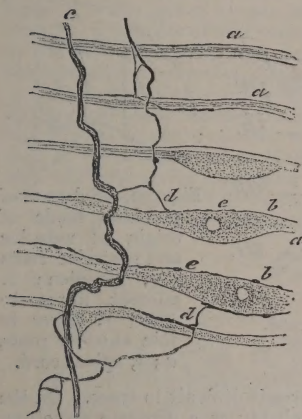


Fig. 95.—Nerve ending in smooth muscle—*c*, nerve; *a*, smooth fibres; *b*, nerve endings in sheath; *e*, nodal swelling.

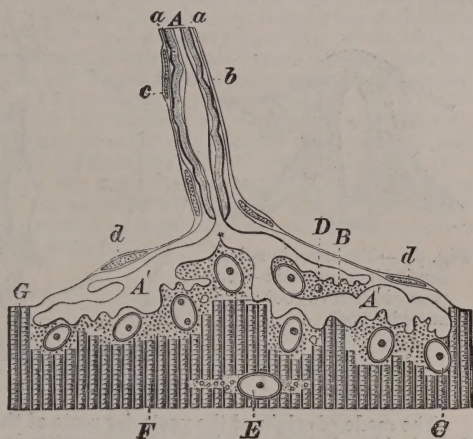


Fig. 96.—Nerve ending in striped muscle—*a*, medullary sheath; *c*, nuclei in Henle's sheath; *A'*, termination of *A*; *E*, nucleus of muscle.

on the substance of the muscle (*F*). Each muscular fibre has at least one such nerve ending, into which occasionally two nerves are traceable. The contraction of a muscle fibre starts from the ground plate.

The size of the nerve bears no definite relation to that of the muscle to which it is distributed. The external rectus oculi muscle is in section thirty times greater than its nerve the sixth, and there are three nerve fibres for every seven muscular fibres. On the other hand, the tibialis anticus muscle is in cross-section 150 times greater than its nerve, and has one medullated nerve fibre for each eighty muscle fibres.

39. DEVELOPMENT OF THE NERVOUS SYSTEM.—The formation of the first trace of the nervous system has been already noticed (§ 11).

When the medullary groove is closed, the neural tube behind the first vertebra is at first uniform in the thickness of its wall, but speedily begins to show regional alterations, and its cavity (*c*) becomes somewhat lozenge-shaped in section, and sagittally elongated. Its wall thickens, owing to the rapid multiplication of its cells, which differentiate into two zones, an inner (fig. 97, *i.z*) of closely set, radially disposed cells, which become specially modified into the non-nervous tissues of the central system, such as the lining cells of the central canal and the neuroglia cells; and an outer incomplete stratum (*o.z*), of sagittally or longitudinally directed cells, on each side, which does not extend from one side to the other, either in front or behind the central canal. This outer layer at each side thickens at its ventral part, and forms an *anterior horn* (fig. 98, *a.h*); it remains thin in the middle, but thickens again behind into a *posterior horn* (*p.h*). The cells of the anterior horn become aggregated in metameric groups, and each sends off a network of so-called protoplasm pro-

cesses and an axis-cylinder process. The white substance which subsequently invests the grey mass of nerve cells, is developed from the axis-cylinder processes of the cells themselves. The metameric bundles of these pass out from the spinal cord, penetrating at first beneath, then into each muscle plate, forming the anterior roots of the nerves (*a.r.*). The branching processes do not arise from the nerve cells until later. One early developed set of processes appears in the outer stratum of cells as arcuated fibres running sagittally from behind forwards, and these are continued across the middle line to the opposite side, making an *anterior commissure* (*a.c.*).

Between the point of emergence of the anterior root and the middle line, a band of white longitudinal fibres becomes developed on each side, and forms the *anterior white column* of the cord (fig. 100, *ac*). These bands grow forwards and project beyond the plane of the anterior commissure, which on this account appears as the floor of a median groove, the *anterior fissure of the spinal cord* (fig. 98, *a.f.*).

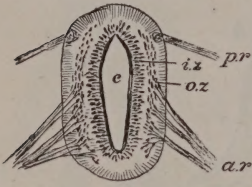


Fig. 97.—Embryonic spinal cord, diagrammatic—*p.r.*, posterior nerve root; *a.r.*, anterior root.

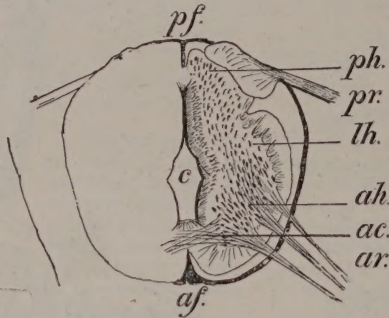


Fig. 98.—Embryonic spinal cord.

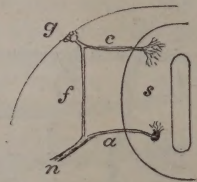


Fig. 99.—Scheme of probable mode of origin of anterior and posterior roots—*g*, ganglion; *c*, afferent fibres to cord; *f*, fibres to join anterior roots, *a*; *s*, spinal cord.

The mode of origin of the posterior roots of the spinal nerves is difficult to trace. On the dorsal side of each anterior root a ganglion is formed, probably as a separate structure, originating from a patch of surface epiblast (or as a separate outgrowth from the outer layer of the cord on each side of the medio-dorsal line). Each cell of the ganglion (fig. 99, *g*) is at first bipolar, the one process being centrifugal (*f*), passing outwards to join the anterior root; while the other elongates backwards centripetally (*c*), and enters the side of the spinal cord on the level of the hinder grey column. These fibres, on entering the cord, constitute the posterior root of the spinal nerve, and are continuous upwards as a white bundle into the *posterior column* of the cord (fig. 100, *pc*). The poles of the ganglion cells become subsequently united into a T-shaped root, so as to make the cells appear as unipolar.

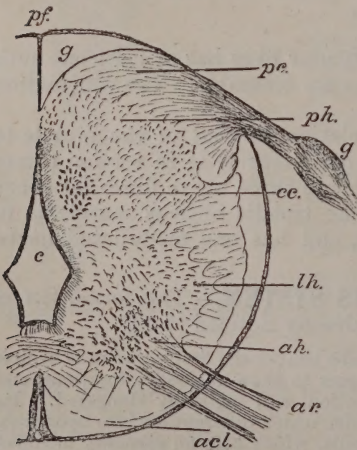


Fig. 100.—Half of foetal spinal cord.

sides of the cord. The *central canal* (*c*) of the cord becomes very narrow, and is lined by ciliated epithelium; the original antero-posterior depth of the cord is shown by the depth of the median commissures.

The grey matter on each side of the cord now appears somewhat crescentic in section, and can be divided into four grey columns:—An *anterior* (*ah*), a *lateral* (*lh*), and a *posterior horn*

(*ph*), and a *postero-internal* or vesicular column—Clarke's (*cc*). The white matter investing it is arranged in four columns:—Anterior (*acl*), lateral, and posterior columns (*pc*), and the column of Goll. Each nerve now appears to arise by two roots, an anterior receiving its fibres from the cells of the anterior and lateral cornua and Clarke's column, and a posterior connected externally with the ganglion, and internally with the posterior cornu.

The foetal human spinal cord is at first of fairly uniform diameter throughout; but, later, as the extremities develop, it exhibits two well-marked enlargements, one opposite the roots of the nerves for the arms, the other at the origin of the roots of the nerves for the legs. These are called the *brachial* and *lumbar enlargements*.

Development of the Brain.—We have seen that the neural tube in the head dilates into three brain vesicles (fig. 19), whose limits are visible even before the closure of the laminae dorsales, and whose relative positions become altered by the cranial flexures (fig. 30). The tissue of the wall differentiates, the inner cells becoming an epithelial lining, the **ependyma**, next to which is an inner grey layer homologous with that of the spinal cord, and surrounded by a layer of white nerve matter, superadded to which is a secondary investing cortex of grey matter. The roofs of the several vesicles consist originally of ependyma and neuroglia, but as the nervous matter from below overgrows and displaces these more purely membranous portions, they become wrinkled and folded, and form the several choroid plexuses.

The cavity of the posterior brain vesicle (fig. 101) is called the **fourth ventricle** (*v⁴*); its floor and sides become the **myelencephalon** or medulla oblongata (*obl*) and the pons Varolii (*ps*), while its dorsal wall becomes the **epencephalon** or cerebellum (*cbl*). The wall of the middle vesicle thickens, and forms the **mesencephalon** or optic lobes above (*bg*), while its cavity becomes a narrow canal, the aqueduct of Sylvius. This portion, which seems to represent the nerve centre of the peristomial segment, with the third pair of nerves as its outgrowth, is the least modified segment of the brain.

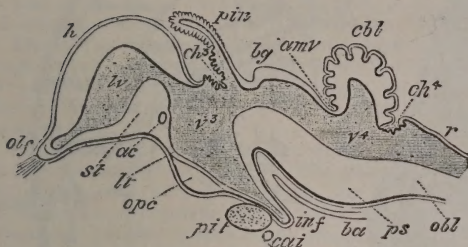


Fig. 101.—Scheme of longitudinal section of brain of embryo fowl. The ventricles are shaded—*ac*, anterior commissure; *amv*, anterior medullary velum; *ba*, basilar artery; *cai*, carotid artery; *h*, hemisphere; *lt*, lamina terminalis; *olf*, olfactory nerve; *opc*, optic commissure; *r*, roof of fourth ventricle.

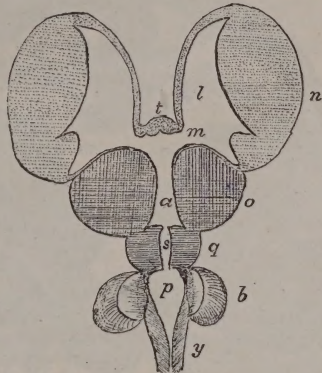


Fig. 102.—Scheme of horizontal section of brain—*t*, lamina terminalis; *q*, optic lobes; *s*, aqueduct of Sylvius; *p*, fourth ventricle; *b*, cerebellum; *y*, medulla oblongata.

The anterior brain vesicle (*v³*) undergoes remarkable changes. On its first closure it is a single cavity, but it soon sends off on each side a ventro-laterally directed hollow outgrowth, the optic vesicle, which projects downwards and towards the surface to meet the optic invagination of epiblast, and to form therewith the eyeball. In front of this the cavity becomes divided into two parts, a smaller hinder or thalamic (the third ventricle, fig. 102, *a*), and a larger fore or cerebral portion (*l*). Of the former, the floor is elongated into the stalks of the optic vesicles (optic nerves, fig. 101, *o*); and posteriorly, it forms a funnel-like process (*inf*), which medially touches the fundus of the oral invagination (*pit*), and forms the pituitary body or hypophysis. The roof of the thalamic cavity remains thin anteriorly, and is supplanted largely by the overlying layer of vascular connective tissue, called the *velum interpositum* (*ch³*); posteriorly, the roof is prolonged into a median pouch which projects to the surface, at whose fundus a rudimental sense-organ is developed which never becomes functional in the vertebrate, remaining in the adult as the *pineal gland* (*pin*). This segment of the brain is the *thalamencephalon*, and the thickened sides of the cavity constitute the optic thalamus (fig. 102, *o*).

The anterior or cerebral part of the anterior vesicle (*prosencephalon*) becomes divided by the ingrowth of a sagittal median involution into two lateral parts, the cerebral hemispheres (fig. 102, *n*). The floor of each of these thickens and forms the *corpus striatum* (fig. 101, *st*), and the roof expands, growing more quickly than its enclosing sheath of mesoblastic tissue, and therefore becoming convoluted, the lines of folding indicating the areas of most rapid superficial growth. The central cavities in these hemispheres are called the *lateral ventricles*, and as the hemispheres become doubled upon themselves or rotated backwards, so these cavities extend backwards, over the thalami, their communication with the thalamic cavity narrowing to a small opening, the *foramen of Monro* (fig. 103, *m*).

The nervous system is that which binds all parts of the body into one harmonious and sympathising unity. Each structure is connected with some nerve cell, and the groups of nerve cells are connected with each other.

Each metameric segment of the body consists of—1st, an epiblastic investment exposed to external impressions; 2nd, the muscles developed from the somatopleure; 3rd, the visceral structures derived from the splanchnopleure, with their vessels, muscles, glands, and mucous surfaces. Correlated with these parts there are in each segmental nerve three sets of fibres—(1) sensory or afferent, conveying impressions from both the somatic and splanchnic surfaces; (2) motor, with large ($13-18\mu$) medullated fibres, to the somatic muscles; and (3) visceral

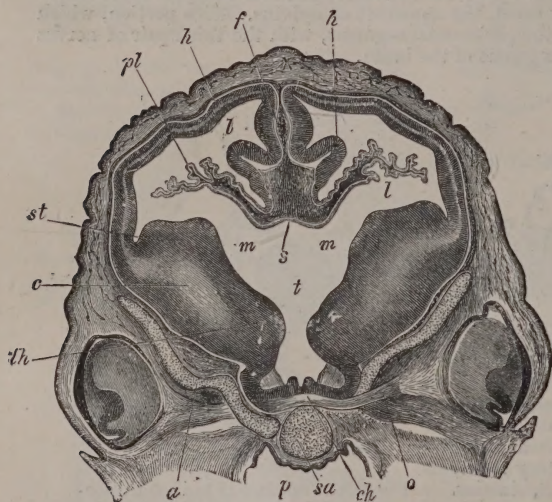


Fig. 103.—Transverse section of foetal lamb's head $\times 10$, showing optic vesicles—*a*, orbitosphenoid cartilage; *sa*, presphenoid; *c*, fibres of crus cerebri; *ch*, optic commissure; *f*, fissure between two cerebral hemispheres, *h*; *p*, pharynx; *th*, optic thalamus; *pl*, choroid plexus on each side of velum interpositum, *s*.

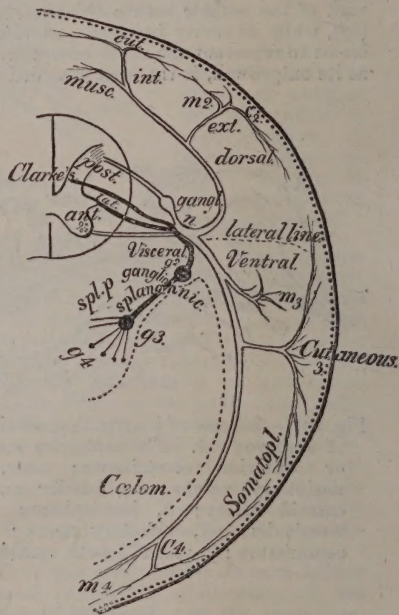


Fig. 104.—Scheme of column of grey matter in the nervous centres and of the nerves arising therefrom.

branches, to the parts derived from the splanchnopleure or upon the same horizon. These are twofold, one set consisting of small ($3-8\mu$) medullated fibres, are distributed to the striped muscles of the viscera without passing through intermediate ganglia, the second set form ganglia from which the fibres of distribution arise.

Each segment of the body had originally its own metameric nerve, springing from its own ganglionic centre. There are also connected with each metameric nerve two sets of ganglia—one the fixed ganglia of the posterior root, connected with the afferent nerves; the other the vagrant ganglion of the efferent splanchnic fibres.

The first series form the posterior root of the nerve and pass into the spinal cord to end in the substance of the posterior horn of grey matter (fig. 104), the second form part of the anterior root and arise from the anterior horn, while the visceral have a three-fold source,

partly from the lateral horn, partly from the column of Clarke, and partly from solitary cells at the base of the hinder horn. The second or gangliated set of these visceral nerve fibres separate from the rest of the spinal nerve shortly after its exit from the spinal canal, and pass into a ganglion on the ventro-lateral side of each vertebra (fig. 104). In each of these vertebral or sympathetic ganglia many of the medullated fibres become non-medullated. Branches from these ganglia form a second or prevertebral chain at the root of the splanchnopleure, and from these the branches of distribution arise and form a series of minute terminal ganglia in the viscera. The visceromotor nerves probably arise from the cells at the base of the hinder horn and from the small cells of the lateral horn; they run into the vertebral chain of ganglia. The vaso- and visceroinhibitory branches probably arise from Clarke's column, and pass through these to the distal ganglia.

On the other elements in the anterior roots there are no ganglia. It is significant that the nerves supplying the viscera arise closer to the central canal, while those supplying the somatopleure are connected with the outlying horns of grey matter.

Owing to the displacement and condensation which the various segments that make up the head have suffered, these nerve elements have undergone serious mutations in the cranial region, and the relation of the twelve pairs of cranial nerves which exist in the adult to the primitively segmented type have become obscured. It is probable, however, that they are the re-arranged fibres of an originally simple series of at least nine segmented nerves.

These may be grouped in two series—1st, segmental nerves with atrophied elements; and 2nd, re-arranged nerves, in which the elements of the same kind in successive segmental nerves have coalesced into single cords.

Of the first series there are four. The nerve of the first segment is the motor oculi or third pair, which consist of a large-fibred, non-ganglionic somatic efferent part and a small-fibred splanchnic motor part, with a vagrant ganglion, the ciliary. The afferent elements are only present as atrophied rudiments. The second segmental nerve, the fourth pair, resembles the third, but has no vagrant ganglion; that of the third persists as two parts, its somatic motor part remaining as the sixth nerve; the splanchnic non-gangliated small-fibred portion is the motor division of the fifth, in connection with which there are rudiments of the obsolete afferent ganglion. These nerves belong to the mandibular segment.

The nerves of the fourth or hyoid segment have no motor somatic element; the non-gangliated small-fibred splanchnic motor fibres constitute the seventh or facial nerve, while the gangliated splanchnic element forms the ganglion geniculatum and the fibres thereto connected. The afferent ganglion is present as a degenerated rudiment in connection with the seventh.

In the second series, the motor somatic fibres of probably five nerves have united to form the hypoglossal or twelfth pair. The afferent somatic have united to form the sensory portion of the fifth with its ganglion, the Gasserian; the afferent splanchnic branches have united to form elements of the ninth and tenth nerves, and keep their ganglia as those of Ehrenritter and the radical vagus ganglion respectively. The gangliated efferent fibres also form fibres of the ninth and tenth, having their vagrant ganglia as Andersch's and the trunk vagus ganglion, while the non-gangliated splanchnic fibres have united to form the eleventh pair. The details of these relationships will be better understood in connection with the descriptive anatomy of these nerves.

The branching of a typical metameric nerve may be represented as in fig. 104. The lateral muscular and lateral cutaneous nerves of those metameres from whose somatopleure the limbs are outgrowths, are continuous into these appendages, and as the musculature of the adult limb has been moulded into its present arrangement by those successive complex fissions and recombinations of the primitive bundles of the primitive limb, which have been taking place through the whole paleontological history of limb-bearing vertebrates, so the nerves bear traces of these mutations by their unions into tangled networks called *plexuses*. Nerve plexuses are threefold—(1) root plexuses, such as those formed by the nerves on their exit from the vertebral canal; (2) stem plexuses, formed on the course of a nerve, such as the oesophageal; or (3) terminal plexuses, such as are found in most organs. The presence of a root plexus at the base of a limb indicates—1st, that muscles and nerves from several metameres go to that limb; 2ndly, that the metamERICALLY separate slips of muscle have at some period been fused into a sheet; 3rdly, that this sheet has undergone a primary segmentation into posterior and anterior lamellae, corresponding to which the nerves are similarly divided; 4thly, that of the segments thus formed some have reunited, while others have joined fascicles which were at first remote and heterogeneous and have undergone still further subdivision.

There are twelve pairs of cranial and thirty-one of spinal nerves in man—eight cervical, twelve dorsal, five lumbar, five sacral, and one coccygeal. The first cervical comes out between the skull and the first vertebra; each succeeding nerve makes its way out between two contiguous vertebræ, the last escaping between the last sacral and first coccygeal vertebra.

Until the fourth month the spinal cord is coextensive with the vertebral canal; but the rate of growth of the latter exceeds that of the former, so that at birth the end of the spinal marrow is opposite the lower border of the second lumbar vertebra. In the adult the spinal cord ends opposite the lower end of the first lumbar vertebra.

With the shortened spinal cord, the roots of the nerves corresponding to the lower vertebræ become lengthened, and the nerves are drawn into the canal, and run alongside of the end of the spinal cord, making the *cauda equina*. The axial termination of the spinal cord is a very fine thread, the *filum terminale*.

The tissue derived from the mesoblast which surrounds the brain and spinal cord has become condensed and laminated into the three membranous envelopes for the nervous centres. The layer in contact with the surface of the brain and cord is named *pia mater* (fig. 105, *p*), and consists of circularly directed and often angularly bent bundles of white fibrils, covered on each surface by a delicate interlacement of elastic fibrils, and clad both without and within by endothelial cells. Many blood-vessels ramify on the outer surface (*v*), sending fine branches through the membrane to enter the underlying nervous tissue, carrying with them delicate sheaths of the membrane, which bound perivascular lymph spaces.

In the spinal canal, a tough outer layer of longitudinal fibres is superadded to the deep circular layer, and is also clad with endothelium, and separated from the underlying lamella by more or less continuous lymph spaces.

Outside the *pia mater* is a wide-meshed trabecular tissue, sometimes broken down into a continuous cavity, the *subarachnoid space* (*s.a*), filled with a serous

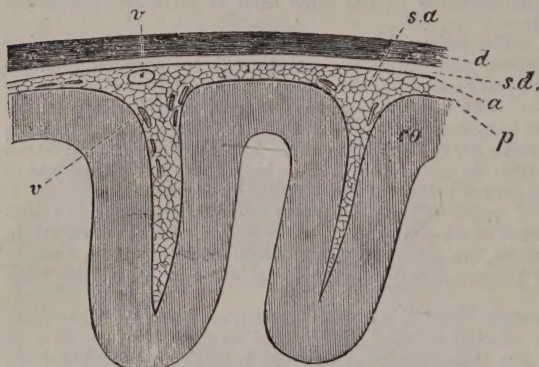


Fig. 105.—Section of the connective envelopes of the brain.



Fig. 106.—Section of brain membranes on one side of the superior longitudinal sinus.

subarachnoid fluid, and limited externally by a second delicate connective layer, the *arachnoid* (*a*). This consists of several layers of interlaced flat bundles of connective fibrils, whose meshes are filled with endothelial cells. On its outer surface in certain regions (especially along the superior longitudinal sinus) are villous processes of lymphoid tissue, liable to enlarge and even to bulge through

the dura mater with advancing age. These are called *glandulae Pacchioni*, and they seem to depend on the differing degrees of *subarachnoid* and *intravascular tension*. According to Gaskell they are possibly homologous with the degenerated remains of the arthropod liver.

Outside the arachnoid is a continuous lymph space, the *subdural cavity* (*sd*), bounded externally by a strong, tough, white, fibrous membrane, the *dura mater* (*d*), the firmest of all the membranous envelopes of the brain. This membrane also consists of closely united lamellæ of white and yellow fibres, in whose meshes are lymph canals, which, like both surfaces of the membrane, are lined by endothelium. Within the cranium, this membrane is in most places attached to the inside of the skull; but in the spinal canal, it is surrounded by an interrupted *epidural* lymph space.

MUSCLE.

All living masses of protoplasm which are not limited by an investment of metaplastm are capable of amoeboid motion in all directions (fig. 107); but in certain cells the organisation of the protoplasm is such that contraction can only take place in one direction. These cells constitute muscular tissue.

The differentiation of muscle and nerve is the morphological result of a physiological division of labour, whereby the unit of protoplasm, in which irritability and contractility are combined, has, on the one hand, become modified into muscle, which retains the property of contractility, and on the other, into nerve, which retains that of irritability.

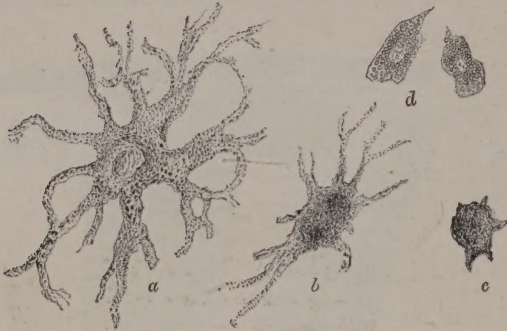


Fig. 107.—Pigment cell with pseudopodial processes.

Fig. 108.—Contracting pigment cells.

The muscular system is developed from the mesoblastic muscle-plates and from the mesoblast of the walls of the coelom outside the plates; the cells of these are at first indifferently, but speedily become elongated into muscle cells. Some of these persist (fig. 109) in a simple form as fusiform cells with elliptical nuclei (N), constituting **unstriped muscle**.

These cannot be made to contract by the impulse of the will, and hence are called *involuntary*. In the wall of the heart the cells become shorter, thicker, transversely striated, and joined end to end, constituting **cardiac muscle** (fig. 111). For the most part, however, the muscle cells lengthen into polynuclear, transversely striated fibres of **striped muscle** (fig. 114), which can be made to contract by nerve impulses originated by the will, and hence are called *voluntary*.

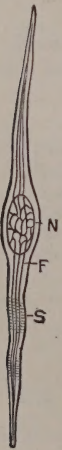


Fig. 109.—Cell of involuntary muscle.

40. UNSTRIPED MUSCLE is found in the substance of nearly all organs, in the coats of blood-vessels, and in skin. Its cells are prismatic or flattened in section, with pointed or bifid ends, and are united into bands by a minute quantity of an elastic cement. These bands are united by areolar tissue into bundles, networks, or lamellæ, permeated by close, oblong-meshed plexuses of capillary blood-vessels, and by lymph spaces of varying sizes, sometimes wide-meshed and numerous, as in the muscular wall of the jejunum, sometimes scarcely discernible, as in the muscular coats of the smaller veins.

Each muscle cell (fig. 109) contains an elliptical central nucleus, which is non-contractile and sometimes flattened, having within it a distinct intranuclear network and one or more nucleoli. The nucleus becomes rod-shaped when the fibre is hardened by reagents. In the protoplasm of the cell is an extranuclear

network, whose strands are mostly longitudinal (F). Some of these threads appear to be attached through the granular protoplasm at the poles of the nucleus to the intranuclear fibres. The whole cell is invested by a homogeneous elastic sheath, which appears faintly wrinkled when the cell contracts (S).

A non-medullated nerve fibre is applied to each cell, and seems to enter it, ending indistinctly in a minute swelling near the nucleus (fig. 95). Unstriated cells show all possible gradations from the round cells of unmodified mesoblast to the long fibre cell of the intestinal wall, .24 mm. long and .007 broad. Many varieties of form and size can be seen in the developing tissue of the wall of the pregnant uterus.

41. CARDIAC MUSCLE (fig.

111) consists of irregularly cubical cells about .08 long, some of which divide at the points where they touch their neighbours above and below, and so the tissue formed by their union appears reticulated, with slit-like lymph spaces between the cells. Each cell has a large, oval, central nucleus, with an intranuclear network, and in the surrounding cell-substance, which has no perceptible cell-wall, the extranuclear reticulum consists of both longitudinal and transverse strands.

Under the endocardium in the right ventricle, close to the base of the tricuspid valve, there are a few larger polynuclear cells (fibres of Purkinje), in which the appearance of striation is limited to a portion of the surface, while the interior is simply protoplasmic.

42. STRIPED MUSCLE.

—The form-elements of this tissue have become lengthened into cylindroidal fibres, .01 to .07 mm. in breadth, and from 1 mm. to 4 cm. in length. They end in bluntly-pointed extremities, sometimes forked, as in the lips, or branched, as in the tongue. Each fibre is invested by a tough, elastic, homogeneous sheath, the **sarcolemma** (fig. 113, S) which is more tenacious than the contractile substance, and is attached by a cement substance to the sarcolemma of the neighbouring fibres, or to a strand of fibrillar tissue. Each fibre appears to be both transversely and longitudinally striated.

The contractile substance which makes up the chief part of the fibre is a semi-fluid, coagulable material, on whose surface many oval nuclei (K) are embedded in a network of protoplasm under the sarcolemma. This substance is marked at regular intervals by transverse striæ (fig. 114) in the following succession:—1, A thin, singly refracting, dim disc (the **membrane of Krause**), the edges of which appear to be adherent to the sarcolemma; 2, a clear space of a singly refracting substance; 3, a broad, dark disc, doubly refracting; 4, a second clear space like 2; 5, another thin disc, &c.

When acted on by hardening agents, each fibre can be split into fibrils (fig. 113, F), each of which consists of rows of segments like those of the whole fibre; by the action of dilute mineral

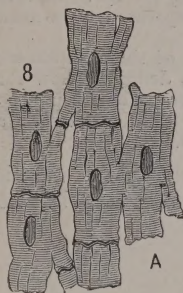


Fig. 110.—Muscle cells from heart, longitudinal view—A, end surface of cell.

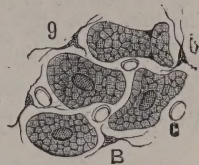


Fig. 111.—Transverse section of heart muscle—B, b, connective tissue cells; c, capillaries.

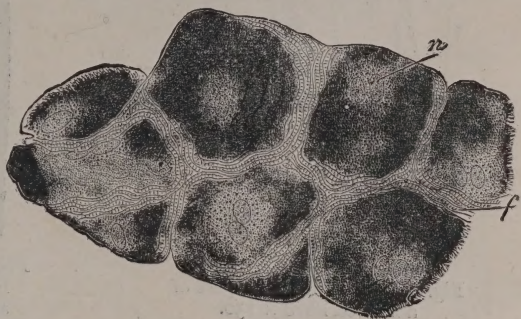


Fig. 112.—Fibres of Purkinje.

acids, a fibre may be divided cross-wise into discs, the cleavage traversing the clear space next to the thin disc. The transverse section of a fibre shows that the component fibrils are collected into highly refracting primitive bundles, whose sections constitute a set of bright dots (Cohnheim's fields), separated by a network whose material is of lower refractive index.

The correct interpretation of these appearances is a matter of much difficulty, and it is not yet possible to pronounce definitely how far they are structural, optical, or artificial. The thin discs appear to be transverse septa, possibly of a material comparable with the anisotropic element of the intracellular network, and to these the longitudinal strands of the broad disc seem to be attached.

One or two nerve fibres (fig. 113, N) pierce the sarcolemma of each muscular fibre, and break up into branching but not anastomosing threads, embedded in

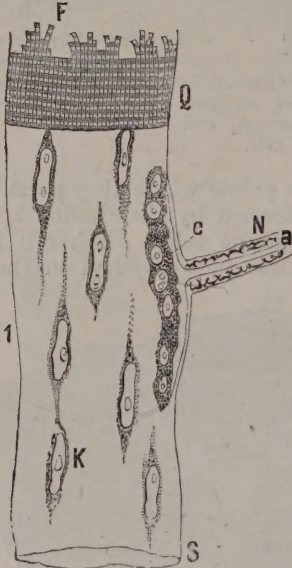


Fig. 113.—Diagram of a part of a striped fibre $\times 150$.



Fig. 114.—Diagram of striped fibre showing alternation of thin and thick discs $\times 300$.

a granular protoplasmic expansion with several nuclei, upon the contractile substance (fig. 96).

43. DEVELOPMENT OF MUSCLE FIBRES.—Each striped muscular fibre begins existence as a singly nucleated cell, which becomes elongated, at first fusiformly, then cylindroidally; and in which the nuclei multiply by division, diffusing themselves along the fibre. On one side of each fibre, the molecules of protoplasm undergo chemical change and mechanical re-arrangement, thereby producing the transversely striated appearance which ultimately spreads through the whole thickness of the fibre.

Fœtal muscles have fewer fibres, but more nuclei than those of the adult. New fibres arise in the earlier stages of growth by the proliferation of nuclei, as well as by the transformation and growth of special cells between the fibres. Multiplication of fibres may occur in any period of a muscle's history, but takes place most actively in the earlier stages.

44. STRUCTURE AND ACTION OF A MUSCLE.—Bundles of muscular fibres are tied together by sheaths of areolar tissue, called *endomysium* (fig. 116, e), and form *primitive fasciculi* (c). Contiguous primitive fasciculi are bound into *secondary fasciculi* by coarser envelopes of connective tissue (*perimysium*, p); and those groups of secondary fascicles which are so connected with each other at their terminal attachments that they act together, and constitute the *muscles* of descriptive Anatomy, to each of which a proper name is given.

These connective sheaths are permeated by an oblong-meshed, capillary

plexus of blood-vessels (fig. 117), providing the large blood supply which is necessary on account of the rapid metabolism that takes place in muscle during

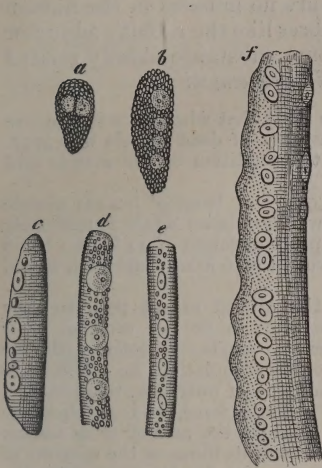


Fig. 115.—Striped fibres in course of development. In *a* and *b* nuclei are multiplying; in *f* one half of the cell has undergone re-arrangement.

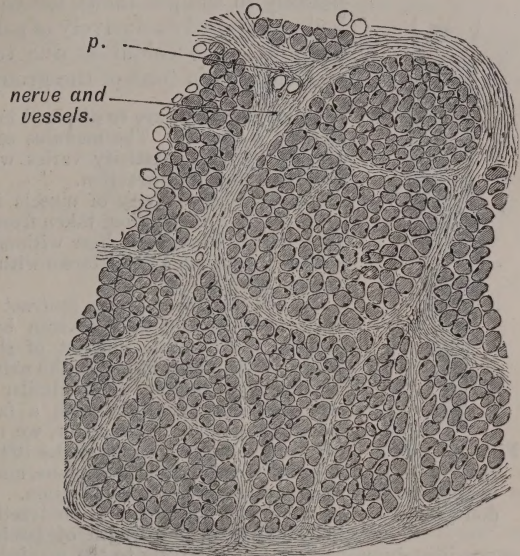


Fig. 116.—Transverse section of a muscle.

action. About $\frac{1}{3}$ of the blood of the body is usually in the muscles at any time. The longest vessels run parallel to the fibres; but they are wavy in course and often present little varicosities on their walls. No vessels penetrate the sarcolemma.

The vascular supply of a muscle is generally in direct proportion to its size, but varies in different parts of the body. In the heart and diaphragm there is 1 sq. mm. of arterial cross-section for every 10 cubic centimetres of muscle; in the biceps brachii there is 1 mm. for each 16, and in the tibialis anticus 1 mm. for each 18. Lymphatics are abundant in striped muscles, beginning as freely communicating wall-less spaces in the endo- and perimysium. The nerves and arteries enter, and the veins and lymphatics leave each muscle at that portion which is least disturbed in position by the contraction of the muscle, and usually on the side farthest from the surface of the body. At this point the muscle is most closely tied to its sheath. Nerves enter quadrilateral muscles near the mid-point of their fleshy fascicles; in triangular muscles the point of entry is nearer the narrower end.

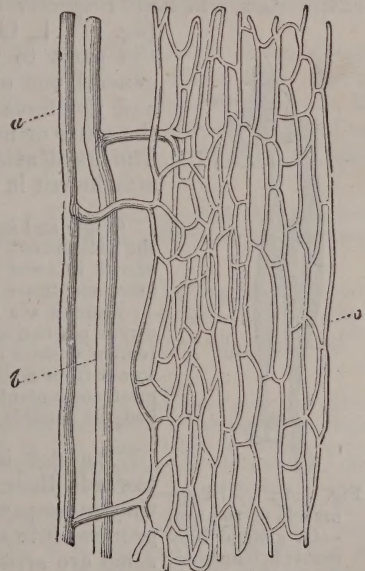


Fig. 117.—Capillary plexus in muscles $\times 250$ —*a*, artery; *v*, vein; *c*, capillaries.

The filaments of fibrillar tissue, which fasten the ends of muscular fibres to the bones or other fixed points, become united into cords or bands, which are called *tendons*; each strand of tendon (fig. 118) is firmly cemented to, and often embraces, the end of the sarcolemma, but is not

structurally continuous with it.

Human voluntary muscles are red, with numerous tortuous vessels between, and many nuclei in, the fibres. Pale fibres are scattered in many muscles, notably in the pectineus, but there are no muscles in the human body composed exclusively of pale fibres like the rabbit's adductor magnus. The colour is due to some substance closely related to hæmoglobin (one of the group of *histohæmatins*).



Fig. 118.—Muscular fibre (12) ending in tendon (S).

Muscular fibres are so disposed in the body that when at rest they are slightly stretched. The modulus of elasticity of dead muscle is 0.2737. During life, the elasticity varies with the condition of the muscle and increases during contraction.

The specific gravity of muscle is 1.041. A band of human muscle 1 sq. cm. in cross-section, taken from a well-nourished adult immediately after death, was able to bear without rupture a weight of 14 kilos.; but a similar band from a child broke with a weight of 6 kilos., and from an old woman with 4.

When human muscles contract to the utmost extent permitted by their attachments, they shorten by from 40 to 60 per cent. of their length, the absolute amount of shortening varying directly with the length of the fleshy fascicles, the nature of the stimulation, &c. The fibres making up a muscle, under similar conditions of nutrition, temperature, and weighting, contract with a fairly definite force, and as they are tolerably constant in diameter, we may consider the area of cross-section of a muscle taken at right angles to the plane of its fibres as the measure of the number of fibres in each plane, and as proportional to the force which the muscle can exercise in contraction. In human muscle, a weight of 9 kilos. prevents the occurrence of contraction of a fascicle 1 sq. cm. in section.

Sectional area and length of fascicle may, therefore, be considered as approximately proportional respectively to the maximum weight which the muscle can lift, and the maximum space through which it can be lifted.

Every muscle consists of a **belly** or middle portion (fig. 119, R), and two extremities, which are respectively attached to bone, fascia, ligament, or soft part (fig. 119, L, U). When the belly contracts, it drags equally the parts to which both extremities are attached; but in general one of these is fixed, so that it cannot be moved, and the force is consequently expended in approximating the other or movable end to the fixed attachment (fig. 126). The fixed attachment is known as the **origin**; the movable attachment is called the **insertion**.

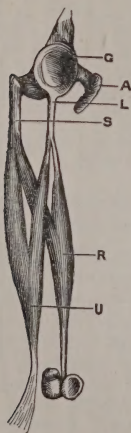


Fig. 119.—Biceps muscle of the arm—G, glenoid ligament; L, long head; S, short head; A, acromion process; R, radial belly; U, ulnar belly.

Origin and insertion are physiological terms; but since the origin is the attachment nearer to the axis and the insertion that more remote, except in some muscles of the neck and back, so *axial* and *abaxial* attachments are the morphological and usually equivalent terms.

Muscles are usually attached to bones by tendons, rarely by the direct cementing of the fibres to the periosteum. Attachment by tendon enables a muscle to exert its influence on a limited area, and to act from a distance, so that its fleshy belly may be packed in the most convenient place, and may be removed as near the axis of the body as possible for convenience of nutrition and innervation.

Muscles inserted into soft parts draw these directly towards their bony attachments; when attached to bone, they must pass over a joint, around which they are generally grouped into sets, some of which act together (*synergists*), and some are arranged so as to oppose one another (*antagonists*).

Each muscle generally acts as a unit, so its force may be considered as acting in the line of the resultant of the forces which each of its component fascicles exerts.

A muscle passing over one joint (fig. 120, b) may produce one of three effects—(1) it may move *ba* to *bd*; (2) or *bc* to *be*; (3) or both *ba*

and bc to bd and be respectively. In these cases, the resulting useful work depends on (1) the amount of the force of contraction, which is proportional to the area of cross-section, and (2) the mode of application of the force.

In the elbow joint (fig. 121) between the humerus (ab) and the forearm (bc), the effective force of the *brachialis* muscle (de) to bend the elbow, equals the absolute force of the muscle, multiplied by the perpendicular drawn from b on de ($= f \sin \phi$). As the angle varies in

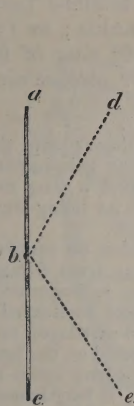


Fig. 120.—Diagram of a muscle passing over one joint.

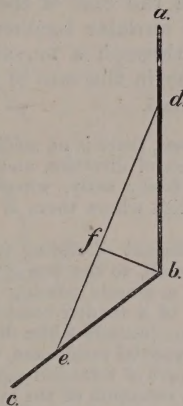


Fig. 121.—Diagram of muscles in front of the elbow joint.
 ϕ = the angle, $d e b$.

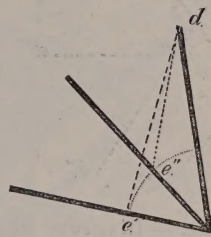


Fig. 122.—Scheme of elbow in flexion.

each position of the elbow, it is plain that the available force will also vary, being a maximum when cb coincides with fb ($\phi = 90^\circ$), and a minimum when the shortening of de is greatest—that is, in extreme flexion (fig. 122, de'').

Each muscle acts to the greatest advantage when the line of its resultant forms a right angle with the axis of the bone into which it is inserted. Even in the state of perfect extension, owing to the thickness of the articular ends of bones, the tendon of a muscle passing over a joint is never perfectly parallel to the axis of the bone, but is stretched over the bulging end as over a pulley, and thus acts at an appreciable angle.

In accordance with the principle that $p : w :: wf : pf$, it is important that the insertion of a muscle shall be as far as possible from the fulcrum, but the magnitude of pf is limited by the shape of the limb.

A muscle passing over two joints (fig. 123, b and c) will, by its contraction, alter the position of the bones to which it is related in one of at least seven possible ways. The line of the limb may be altered from $abcd'$ to (1) $abcd''$, (2) $abc'd'''$, (3) $abc'd''''$, (4) $a'bcd'$, (5) $a''bcd'$, (6) $a'''bcd'$, or (7) $a''b'cd''$.

A muscle acting over two joints is superficial to its synergists which act over one only. A muscle acting over two joints which it moves in opposite directions, is rarely long enough to permit the complete action of the two joints at the same time in antagonistic directions; thus, the hamstrings are too short to allow the simultaneous extension of the knee and flexion of the hip. This condition is called *passive insufficiency*. On the other hand, a muscle passing over two joints which move in the same direction (such as the wrist and fingers) may be so relaxed by the extreme simultaneous flexion of these joints, that the greatest possible shortening of its fibres will not enable it to produce any effect; this is called *active insufficiency*.

Groups of synergetic muscles may be divergent, convergent, or parallel, according to the special circumstances of the joint. The course of the fascicles in a muscular belly (except in the cases of hollow muscles or sphincters) is usually direct from tendon to tendon; when curvature exists, it is generally gentle over a swelling roundness of bone.

The tendon of a muscle often requires to have its direction altered, and

under such circumstances it becomes enclosed in a synovial sheath, or stretched over a bursa to diminish friction. Pulleys to alter the direction of tendons may be of three sorts:—(1) most commonly, the tendon plays over a smooth

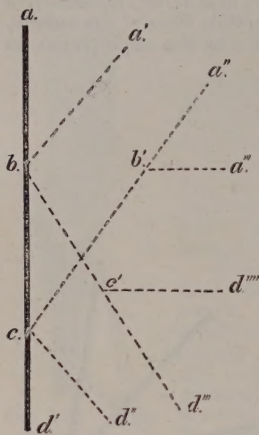


Fig. 123. — Diagram of muscle acting over two joints, b and c.

area of bone, either cartilage-clad or covered by a bursa, as in the case of the *obturator internus*; or (2) the tendon may work through a fixed fibrous loop, as in the case of the extensor tendons passing under the annular ligament of the ankle; or (3) it may pass through a movable swinging ring of fibro-cartilage, as in the case of the *superior oblique* muscle of the eyeball.

In all cases, there is no mechanical advantage except that of the alteration of direction and the consequent gain in packing the bulky, fleshy belly, whereby the force of a long muscle can be applied where there is no room for its being directly placed.

The coefficient of sliding friction of tendon on cartilage is extremely small, so the loss of effective force from friction in the case of a muscle passing over a pulley is inappreciable. The sheath of a tendon consists of a layer of condensed connective tissue (usually white fibrous or fibro-cartilage), around a lining of synovial membrane, which is reflected on the tendon. When any part of a tendon moves through a long space in its sheath, this reflection of the synovial sheath is lengthened and divided into strings (*retinacula*). The length of a retinaculum is the measure of the relative mobility of the points to which it is fastened. When two tendons lie within the same sheath,

if they are separately movable they are each joined to the wall by retinacula, but are not united together, their smooth synovial surfaces gliding the one on the other. If they always act together, then the reflections of synovial membrane from one to the other appear as smooth fibrous bands uniting them (*vincula*).

When several forces act at different angles on one spot in a capsular ligament stretched over a bony surface, that spot grows in vascularity and becomes ossified from increased nutrition, forming a **sesamoid bone**; the patella and the ossicles at the metacarpo-phalangeal joints of the thumb and great toe are examples.

The skeleton forms the fixed basis from and on which the muscles act. If the fleshy fibres of the muscles of an adult man were directly attached to the surfaces of his bones, they would require an area of about 15,000 square centimetres for their attachment. The average adult human skeleton presents a surface of about 12,500 sq. centimetres, of which more than half is from its position unfit to give attachment to muscles, hence the available surface is really less than half that which is required. The attachment of muscles by tendons compensates for this disproportion, as thereby a large number of fibres can be fastened to a small area of bone. As osteoblasts often extend into the attached ends of tendons, so increased bony growth usually takes place along these areas of insertion, which therefore appear on the bones as lines, crests, &c. Sometimes the insertion of a large tendon has hereditarily induced the embryonic cartilage to grow out into a knob: entochondral ossification may independently arise in such a process, producing a new centre of ossification which is called an *apophysis*. The femoral trochanters are examples of this mode of growth.

45. CLASSIFICATION OF MUSCLES.—The disposition of the component fascicles varies in different muscles, and their shapes and modes of action are thereby modified. The following are the chief types met with in the human body:—

1. **Quadrilateral or prismatic** muscles are those whose fibres are parallel, and run directly from origin to insertion. The fascicles of such muscles act as so many parallel forces which can be reduced to a single resultant, having a force equal to the algebraical sum of the forces of the parallel fibres (nf), and in the line joining the centres of gravity of the

areas of origin and insertion. The *thyro-hyoid* (fig. 124) is an example, but there are few such muscles in the body.

In the abdominal wall, quadrilateral muscles are expanded into lamellae, which form part of the wall of the cavity. In such a case, the fascicles form not a plane but a curved surface, and are arranged for a twofold office:—(1) To resist the perpendicular pressure of the contained viscera; and (2) by their contraction, to produce a normal pressure on the contents of the cavity. If, in these cases, the curve of the wall were that of a spherical dome, the pressure would be the same in every azimuth at each point; but in the

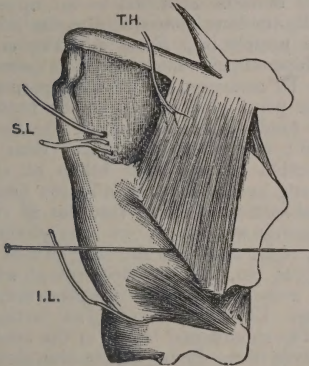


Fig. 124.—Thyro-hyoid muscle of larynx—T.H, thyro-hyal branch of the hypoglossal nerve; S.L, superior laryngeal vessels and nerve; I.L, external laryngeal nerve. The pin is passed under the tendinous arch of origin of the muscle.

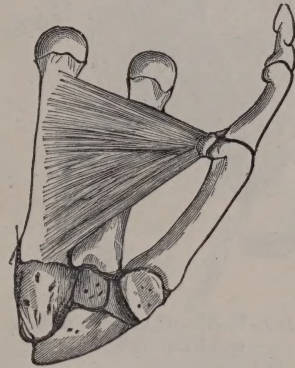


Fig. 125.—The adductor pollicis transversus, a triangular muscle.

abdominal wall the curve is rather that of an ellipsoidal dome; and, consequently, while the perpendicular pressure is constant, the tangential pressure differs in different azimuths, being greatest at the extremities of the major, and least at the extremity of the minor axis of the indicatrix ellipse, and proportional to the squares of the axes. The thickness of the muscle varies accordingly.

2. **Triangular** muscles are those in which the fascicles from a wide origin converge to a narrow insertion. In these the cross-section at right angles to the course of the fibres, when taken before the level at which the tendon begins, is fairly constant. Thus, in the case of the human *great pectoral*, where the line of section is

295 mm.	long,	the muscle is	2.3 mm.	thick	=	6.785	sq. cm.	sectional area.
113	„	„	6	„	=	6.78	„	„
84	„	„	8	„	=	6.72	„	„

When such a muscle contracts as a whole, there is a small difference between the absolute force of the contraction and the amount of force available for useful work, a difference which increases directly with the increase of the angle included between the extreme fibres. In general, this is more than compensated by the advantage of the concentration of the action upon a narrow point, and by the capacity possessed by triangular muscles to contract in parts, and so to produce a variety of action. Hence triangular muscles not uncommonly exhibit radial segmentation.

3. **Fusiform** muscles are such as taper to both ends, the fascicles departing very little from parallelism, and so resembling quadrilateral muscles in their mode of action. The *superior oblique* muscle of the orbit is a good example.

4. **Skew** muscles (fig. 126) are quadrilateral or triangular muscles, the plane of whose line of origin intersects that of the insertion. In such cases, the resultant acts on a spot higher than in an ordinary triangular muscle whose origin and insertion are in the same plane. The adductors of the thigh are examples of this group of muscles.

5. **Rhomboidal** muscles (fig. 127) are such as consist of parallel fibres passing obliquely from origin (o) to insertion (i). In such a muscle the resultant (nf) makes an angle (ϕ) with the line of insertion, and it may be resolved into two components, a horizontal ($h = F \sin \phi$) which tends to approximate the origin and the insertion, and a vertical, or component of translation ($v = F \cos \phi$) which laterally shifts the line of insertion. (F being the resultant

force of the contraction of all the fibres of the muscle.) Some rhomboidal muscles have their fibres inserted at a small angle into a linear tendon, which runs along the margin (fig. 127, i), so that $F \sin \phi$ is small, and the available force exerted is the component of translation ($F \cos \phi$).

Muscles of this kind, such as the *extensor hallucis longus*, from their feather-like appearance, are named **penniform**.

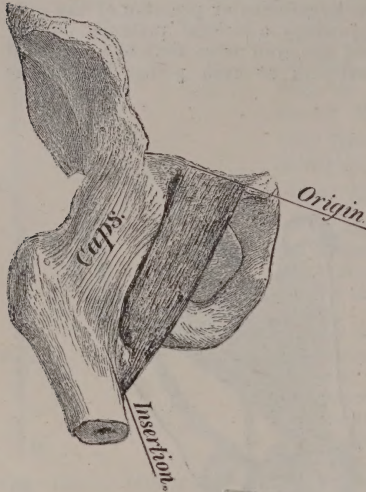


Fig. 126.—Pectineus muscle, a skew quadrilateral.

6. **Bipenniform** muscles are such as consist of two series of penniform fibres attached to a middle tendon (fig. 128), and may be regarded as two rhomboidal muscles attached to the opposite sides of a middle tendon; consequently, the lifting force of such a muscle is $2 F \cos \phi$. The cross-section of a bipenniform muscle, if uniform in thickness, may be measured by drawing perpendiculars from the point of insertion of the topmost fibres into the tendon, on the lines of the lowest fibres produced; this is much greater than the actual cross-section of the mass taken at right angles to its long axis. Thus, in a rectus femoris the area of cross-section of whose fascicles at right angles to their course was 2.45 sq. cm., the maximum cross-section at right angles to the long axis of the muscles was 3.75 sq. cm. The distance through which a bipenniform muscle draws its insertion may be determined thus. Let ax and bz (fig. 128) be the resultants of the two rhomboidal halves of the muscle, of a length l , whose fibres during contraction shorten by a length of δl , and raise x to z on the line of resultant of the whole muscle xy . With b as centre and bz as radius, describe a circle which cuts bz at q ; this shows the absolute amount of

contraction of the fibre $xq = \delta l$. In such a small angle the versed sine may be discarded, so that if zp be drawn at right angles to bz , zp differs so little from the arc zq that it may be regarded as equal to $zq = \delta l$ and the line $xz = \delta l \sec \phi$. As the work done by a muscle = the product of the weight raised by the height, so the work done by a bipenniform muscle = $2 F \cos \phi \sec \phi \delta l = 2 F \delta l$; that is, the bipenniform arrangement in a muscle causes no loss of work, but allows of the packing of a larger number of short fibres in a small space, and their concentration on one point of insertion. So in a slender muscular belly of fusiform shape, like the rectus femoris, there can be arranged a mass of fibres, which can draw its insertion with a quick, strong contraction through a small arc. A prismatic muscle, to produce the same effect, would completely alter the shape of the limb.

Penniform muscles may be formed (1) by the fusion of two originally separate muscle germs, as in the case of the *biceps femoris*; (2) by the prolongation into a muscle-belly of the tendon of origin, as in the *rectus femoris*; or (3) by the upward prolongation of the tendon of insertion, as in the *tibialis posticus*.

Some muscles, like the *subscapularis* and *deltoid*, are compound penniform muscles, made up of groups of oblique fibres passing between tendinous planes.

7. **Sphincter** muscles consist of curved fascicles in one or more planes, surrounding orifices which they close by contraction. They rarely consist of closed ellipses.

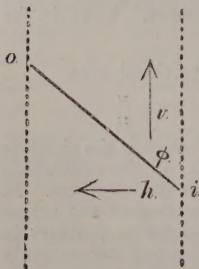


Fig. 127.—Diagram of a rhomboid muscle.

46. DEVELOPMENT OF THE MUSCULAR SYSTEM.—The

earlier stages of the formation of the muscular system cannot be traced in the mammalian embryo, owing to the rapidity with which they are passed through. The formation of the muscle-plates and of the primitive metameric system of muscles has been already mentioned (§ 11). At first, the muscles derived from the plate are not strongly marked off in each segment from those which arise ventrally from the mesoblast of the somatopleure; but eventually a lamella of connective tissue, which grows out from the side of the vertebral body, divides the musculature into two parts, the chief portion of the muscle-plate giving rise to the dorsal muscles; and the ventral end of the plate together with the muscle which arises in the tissue of the somatopleure, to the ventral muscles. In each metamere there is, therefore, on each side a dorsal (d) and a ventral mass or *myocomma*, separated from each other by this transverse connective septum (f_2), and from the segments before and behind by intermetameric septa (fig. 129).

The dorsal muscle undergoes less change than the ventral; but many causes influence the development even of these muscles. The anatomical arrangement of the muscular system is the physical exponent of habitual actions, and these actions are the chief factors in moulding the bones, and in regulating the positions of the somatopleural vessels and nerves. It follows from this, that we need not expect to find in successive metameres more than a generalised resemblance of the component muscles.

The locomotory function and consequent unity of the trunk-muscles were lost when the early vertebrate became terrestrial. In higher vertebrates and notably in man, the mobility of the several regions of the vertebral column differs both in degree and in kind; the outgrowing vertebral processes show consequent variations, and the muscular system is varied accordingly. The changes which the dorsal muscles have undergone are four-fold:—1, Cleavage into separate longitudinal strips (fig. 130, 7, 9, 10, and 11) by the ingrowth of laminae of connective tissue, vessels, and nerves; 2, displacement of the intermetameric septa by overgrowth of some

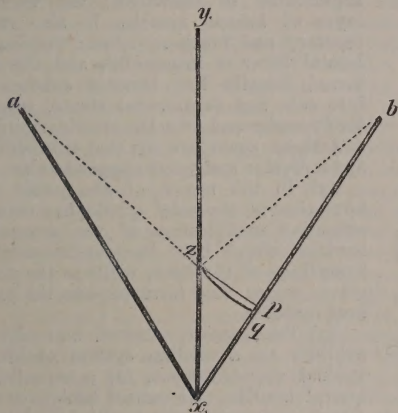


Fig. 128.—Diagram of a bipenniform muscle.

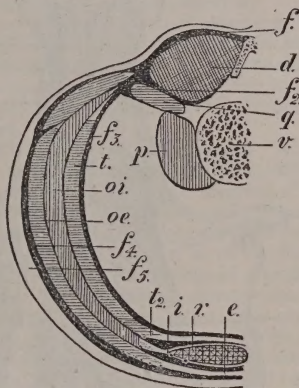


Fig. 129.—Diagram of the muscles of the body wall seen in transverse section—*f*, superficial lumbar fascia.

portions and atrophy of others (fig. 130, 2); 3, the union of successive and contiguous portions into long strips of muscle, which pass through successive segments and which are united either by tendinous intersections, the remains of the intermetameric septa, these strips becoming polygastric muscles, or by the transformation of the connective tissue into muscle, and the formation of long continuous fleshy fascicles; 4, alteration in direction of some of the fibres. As a result of these alterations, the dorso-lateral muscles become broken up into three series:—(1) A deep set of short muscles, attached to the processes of contiguous vertebrae, and varying in obliquity according to the elongation and direction of these processes (17); (2) an intermediate group of longitudinal muscles (9); and (3) a superficial oblique set, attached chiefly to the transverse septum between the dorsal and ventral muscles (14, 19). Most of the deeper oblique fibres run upwards and inwards, but this varies with their mechanical relations.

The dorsal muscles are continued into the head-segments, but in these they have undergone much modification. Those of the first head-segment have become the orbital muscles supplied by the third nerve; the dorsal muscle of the second segment is the *superior oblique* of the orbit; those of the third segment the orbital muscle supplied by the sixth nerve, and the mandibular muscles supplied by the motor root of the fifth.

The ventral muscles have departed from their primitive embryonic arrangement even more than the dorsal. At a very early period in development, an ingrowth of the mesoblastic cells, which clothe the ventral end of the splanchnic surface of the muscle-plate, between the aorta and the sheath of the notochord, has become differentiated into a series of muscles on the ventral aspect of the vertebral column. As these appear distinct from the rest of the ventral muscles, they have been called *hypaxial* or *hyposkeletal*; but they are of small size in man. These hypaxial muscles are essentially splanchnic and are supplied by the small-fibred, non-gangliated motor nerves which arise from the large cells of the lateral horn of the spinal cord. They are the *diaphragm*, *transversalis* (fig. 129, *t*), and *psoas* (*p*), and superiorly in the same horizon are the muscles supplied by the facial and spinal accessory nerves.

The ventral muscles in the wall of the somatopleure have become modified owing to (1) the varying size of the coelom in each region, (2) the development of ribs in the inter-

metameric septa of the thorax, (3) the development of the limb-girdles. For these reasons the arrangement of the ventral muscles differs from that of the dorsal, and presents special characters in each of the six regions of the body.

(1) They are least modified in the *abdominal* region (fig. 129), where they exhibit a primary division into a median or longitudinal group, the *rectus* (fig. 129, *r*), and a lateral which becomes bilaminar—dividing into a superficial or supracostal layer the *external oblique* (*oe*), and a deeper, the *internal oblique* (*oi*), overlying the visceral lamella or *transversalis*.

(2) In the region of the *thorax* the outer layer has undergone immense development, as in it the shoulder girdle is placed, and the dorsal extension of this arch has carried the

ventral muscular layer backward, overlapping the dorsal muscle in this region as far as the medio-dorsal line. In this region there is a median system of muscles represented in rudiment; the visceral layer of lateral muscles is also rudimentary and much modified; the deeper lateral layer is intercostal, and the external lamella has become subdivided into sub- and supra-zonal strata, respectively under and over the shoulder girdle, and these again are divided into dorso-appendicular and ventro-appendicular.

(3) In the region of the *pelvis* the formation of the solid girdle has caused extensive modification of the muscular lamellæ, which have become inseparable from those of the limb, while in the post-pelvic region they have become the perineal muscles.

(4) The *cervical ventral musculature* exhibits (1) a median system of longitudinal segmentations, (2) a superficial, lateral lamella, also carried back over the dorsal muscles to the medio-dorsal line, and (3) a deeper imperfect layer; but its visceral lamella has undergone much displacement and re-arrangement, as the coelom does not extend, except partially, into this region.

(5) In the *cranial* region the ventro-lateral muscles are absent, the whole musculature belonging to the dorsal or the visceral system.

The muscles in the limb are derivatives of the superficial lateral layer of trunk muscles. In Mammalia they appear to arise independently of the muscle-plates and to become subdivided, as the need for separate actions arises.

47. AGGREGATION OF MUSCLE FIBRES.

—The muscular system is the crystallisation of ancestral habit, and the origin of the separate muscles is due to a series of differentiations of very different historic antiquity; consequently, the separate muscles are of varying morphological value. In the development of any layer or segment, according to the degree of closeness with which the fibres of the myocomma are aggregated, the connective

cells which surround them have become endomysial, perimysial, or fascial; and the so-called "muscles" are those groups of fascicles which act together as functional units, each of which is isolated from its neighbours by a plane of connective tissue.

All trunk muscles are primarily *monomeric*—i.e., consist of fibres derived from a single metamere; but by fusion they generally become *polymeric*, the original separate parts becoming inseparable, or divided by surviving traces of the intermetameric septa into two or more

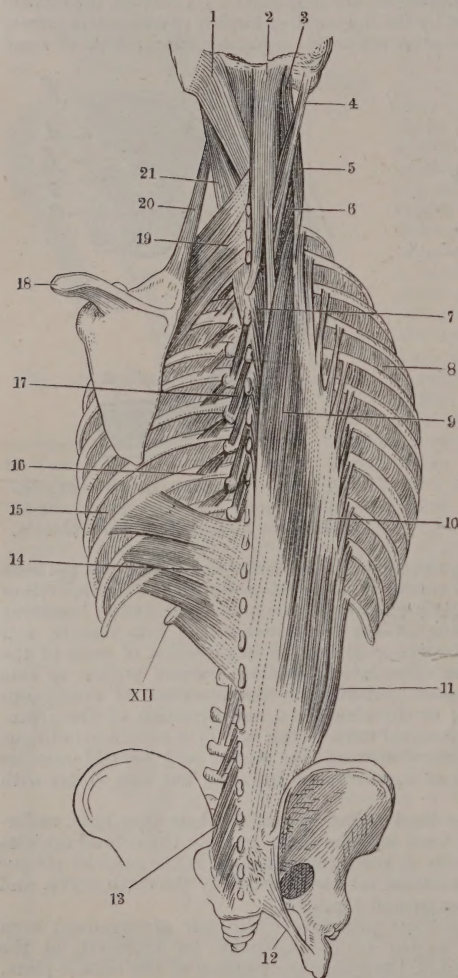


Fig. 130.—Dorsal muscles. For full references see § 148.

bellies. The *longissimus capitis* and *rectus abdominis* are instances of such polygastric muscles. The fascicles of monomeric muscles are primarily *monoplastic*, each the length of a single fibre; but in polymeric muscles they become *polyplastic*, as also in the muscles of the limbs.

Muscle, from its active metabolism, is an expensive tissue for the animal to maintain, so when from change of habit a muscle ceases to be useful, it either atrophies and disappears, or becomes a connective band, or unites with some other muscle. Portions of muscles may also become detached and degenerated, so as to act as ligaments (fig. 114, *if*).

Many muscles have a double function, a primary and a secondary; thus the *biceps* is both a flexor of the elbow and a supinator of the hand. The secondary function of a muscle may be constant, or occasional, the muscle so acting only when the part is in some one position.

Each myocomma is primarily innervated by its own segmental nerve, so that all muscles derived from one myotome are *homoneural*, while polymeric muscles are *heteroneural*.

The adult muscular system of man bears everywhere traces of earlier cleavings and subsequent fusions, partial disappearances, and local overgrowths. As the outcome of these we find that, while most of the limb-muscles are *mononeural*, a few (such as the *brachialis anticus*) are *diplo neural*, deriving innervation from two or more sources; even of the former series only a few are truly homoneural, and many are *crypto-heteroneural*, having strands of supply from several metameric nerves blended into one cord.

Depending on their history is the variety noticed in the mode of origin of muscles. While many muscles arise by a single origin which may be either (*a*) restricted, or (*b*) diffuse, others have two or more separate heads. This many-headedness arises (1) from the wasting of an intermediate part in a primitively continuous sheet; or (2) from the overgrowth and extension of the origin of a primitively simple muscle to some neighbouring and separably movable part; or (3) from the fusion into one belly of several primitively distinct muscles, as in the *biceps* (fig. 119); or (4) from the development of an accessory head from the thickening of a portion of the investing sheath, as in the case of the *rectus femoris*. Polymeric laminated muscles sometimes arise by a succession of fleshy slips, and as the same hard parts often give origin to opposite muscles, we have resulting therefrom the phenomenon of *indigitation* (fig. 130, 14).

There is a like variety presented by the insertions of muscles, which may be (1) by simple tendons, restricted or diffused; (2) by multiple tendons, into (A) dermis, (B) fascia, (C) bone, or (D) into tendinous arcades, when a continuous line of insertion has to be traversed by a vessel, nerve, or other tendon. As both origins and insertions are the creatures of habit, they are both equally variable with variation of function; but as, in higher animals, the kind of work to be done is more constant than its degree, so, as a rule, insertions alter less than origins.

The musculature of the digestive organs is derived from the mesoblast of the splanchnopleure; that of the various parts of the hæmocœlum (heart and blood-vessels) is derived from those cells of the mesoblast which originate at the line of attachment of the splanchnopleure.

In the description of a muscle the following points are to be observed—attachments, texture, nervous and vascular supply, and relations. In the descriptive portion of this work the normal (§ 2) attachments only are specified.

48. BLOOD AND LYMPH are, in a sense, tissues; but as most of the details of the anatomy of these fluids can be studied most profitably in connection with their physiology, only such points need here be noticed as bear on their relation to other tissues. Blood is a viscid, red, opaque, alkaline fluid, contained in a tubular system of vessels, within which its mass is in continuous motion, and its material in a continual state of change.

The average specific gravity of blood in man is about 1·056, and it makes up about 0·77 of his weight; but this is probably liable to much variety, as the co-existence of an arterial system of small capacity with much corpulence is not at all uncommon. The exact quantity of blood varies very little in different stages of the same adult individual, amounting to about 5·6 kilos. in an average man, constituting a bulk of about 4,400 cubic centimetres. Of this mass, at any given time about one-eighth is in the arteries, about one-half in the veins, including those of the liver and spleen, and the remaining three-eighths in the finest vessels or capillaries.

Blood consists of two parts, the **cellular elements** and the **plasma** or *intercellular substance*; the former make up about 51·3 per cent., the latter 48·7 per cent. of the whole. The corpuscles are of two kinds—(A) **Leucocytes**, colourless nucleated cells derived from lymph (fig. 131), which show active amœboid motions, and average 10 μ in diameter. Each cubic mm. of blood

contains about 9,000 in the adult, 19,000 in the infant. The absolute number varies in different parts of the body, and according to the age and condition of nutrition of the individual, increasing in number soon after a meal, becoming fewer during a prolonged fast.

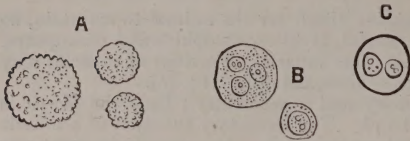


Fig. 131.—White blood corpuscles—A, normal; B, acted on by water; C, by acetic acid.

line, measuring 7.7μ in diameter (fig. 132, C, a b); and about 1.9μ in thickness (C, c d).

The bulk of a corpuscle is estimated at $\frac{1}{100000000}$ of a cubic mm., the surface of each at $\frac{1}{1000128}$ sq. mm., and the weight at $\frac{1}{100008}$ mg. The collective surfaces of all the corpuscles in man have been estimated at 2,816 square metres, and the number of corpuscles at about 25,000,000,000,000.

Red corpuscles in blood at rest tend to cohere into rouleaux (fig. 132, A, 3), and are reddish-yellow when viewed singly by reflected or transmitted light in arterial blood, but slightly greenish when seen by transmitted light in venous blood. The protoplasm has become wholly transformed into two

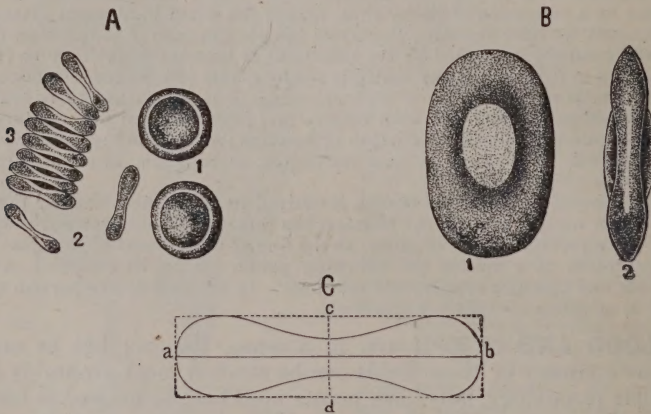


Fig. 132.—Red blood corpuscles—A, human; B, frog's; 1, seen on their surface; 2, seen edgewise; 3, united into a rouleaux; C, ideal transverse section of human corpuscle $\times 5000$.

materials; a colourless, elastic stroma or ground-substance to which the corpuscle owes its firmness, flexibility, and constancy of shape, and a colouring-matter, called hæmoglobin, which varies in tint according as it is, or is not, combined with oxygen. In the former case, it gives to blood a bright scarlet colour, and the blood is called *arterial*; in the latter, it is a deep modena purple, and the blood is *venous*. Capillary blood is intermediate in colour.

Other solid elements exist but more sparingly in blood:—(A) corpuscles of slightly different shapes; (B) blood-plates, which are minute, pale (or slightly coloured), oval, or lenticular discs, about 1 for every 15 red corpuscles, and of much smaller size (3 or 3.5μ); (C) colourless granular masses; or (D) minute elementary granules (*hematoblasts* or *microcytes*).

II. The **plasma** is a clear, colourless, alkaline fluid, capable of making its way through the walls of capillaries. After withdrawal from the body, under

the influence of a ferment derived from the white corpuscles, it divides into two parts, a solid clot of fibrin, in which the corpuscles are entangled, and a straw-coloured fluid or serum whose specific gravity is 1.027, and which makes nearly two-thirds of the bulk of the original plasma.

Blood contains in solution rather more than half its volume of gases; 100 volumes of arterial blood contain 20 volumes of oxygen, 35 of carbon dioxide, and 2 of nitrogen. The same bulk of venous blood contains 10 of oxygen, 45 of carbon dioxide, and 2 of nitrogen. The bulk of the oxygen is combined with the hæmoglobin in the corpuscles, the carbon dioxide is dissolved in the plasma.

Blood is the carrying tissue of the body, and for this purpose the plasma, and under certain conditions the white corpuscles, transude through the coats of the smaller vessels into the spaces which are always present between the cells of the connective tissues. Here this fluid travels, bathing the neighbouring form-elements, and affording them at once the opportunity of taking in nutriment and of getting rid of the products of cellular metabolism. The resulting fluid derived partly from the plasma, partly from the tissues, is named **lymph**, and the intercellular spaces wherein it is contained are called **lymph paths** (fig. 133). Where the latter are confluent within constrained limits (a) they become canal-like intercellular passages (x), and these by coalescing lead into tubular canals called **lymphatics** (L), which collect and return the lymph into the blood. Lymph is thus extravascular plasma, differing from blood plasma in containing less albuminous material, and holding also the waste elements derived from the tissues, having also the nucleated, but not the non-nucleated corpuscles. If we may judge from the relative capacities of the capillaries and lymph spaces, there must be about as much lymph as true blood in the body.

It would be genetically more accurate to reverse the statement of the relationship and to call blood intravascular lymph, in which are contained red corpuscles. Lymph may be regarded as the primary nutrient fluid, and blood as lymph *plus* a respiratory provision in the form of the non-nucleated corpuscles, for the conveyance of oxygen to the tissues.

The earliest blood-corpuscles of the embryo are masses of protoplasm around large nuclei, derived by proliferation from mesoblastic cells in the vascular area. In later periods of embryonic life, these are replaced by the non-nucleated blood-discs, developed (1) by the transformation of coloured portions of the protoplasm of pale cells in the red marrow of bones; (2) by a similar process in other embryonic connective tissues (fig. 23); (3) possibly by the transformation of the nuclei of white corpuscles, or of the colourless hæmatoblasts, but this is improbable.

Changes in the corpuscles, as yet not definitely understood, take place in the spleen, liver, and other organs. The white corpuscles chiefly arise in lymphatic follicles and lymphatic glands, and from thence are introduced into the blood.

In certain regions where foreign materials are brought in contact with membranous surfaces, they enter the intercellular spaces and are carried into the lymph paths. Thus medicinal agents applied to the skin become absorbed, and hence the lymphatics are

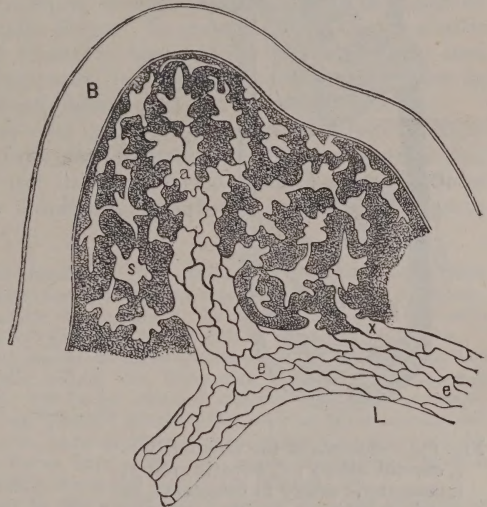


Fig. 133.—Lymph paths in central tendon of diaphragm—s, lymph space; x, opening of lymph space into lymphatic; B, blood vessel.

named absorbents. As from the nature of the case, the lymphatics of the digestive canal are thus constantly engaged in carrying the fatty products of digestion into the circulation, their fluid assumes a special character from this admixture and is called **chyle**; while the vessels carrying it appear white on account of the chyle shining through the transparent walls, and are called *lacteals*.

Chyle consists of fat granules and lymph corpuscles, suspended in a fluid identical with the plasma of lymph.

49. CIRCULATION.—The blood circulates in a system of closed tubes derived from the hæmocœlom, starting from the heart as a centre (fig. 134). The heart consists of four cavities—two **auricles** or receptive cavities (*m, t*),

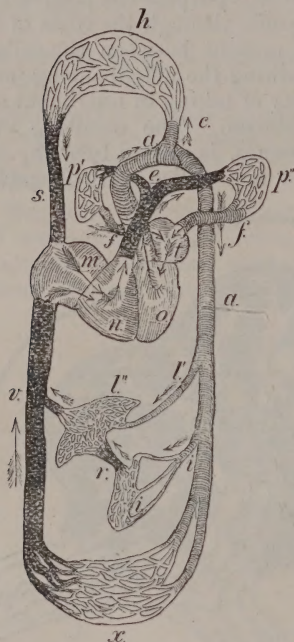


Fig. 134.—Scheme of the circulation—*c*, carotid artery; *l'*, hepatic artery; *i*, mesenteric artery to intestine *i*, in which it forms a capillary plexus, from which the blood passes by *r*, the vena portæ, to *l''*, the liver, there to pass again through a capillary plexus.

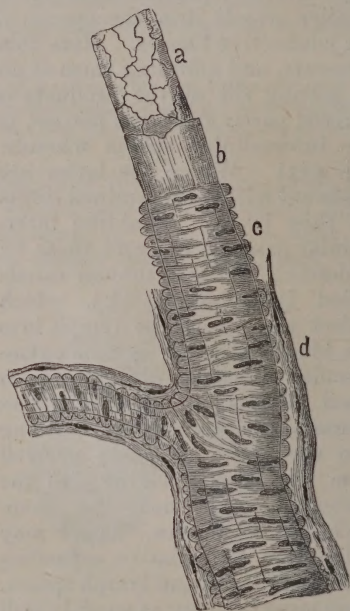


Fig. 135.—Scheme of the coats of a small artery.

and two **ventricles** or propulsive cavities (*n, o*). The oxygenated or arterial blood is propelled by the left ventricle (*o*) into the aorta (*a*), and from thence into the arteries, which convey it to the ultimate vessels or capillaries (*h, x*), where it nourishes and aerates the tissues, and from which it is returned by the veins (*s, v*) into the right auricle of the heart (*m*). From thence it enters the right ventricle (*n*), which drives it into the lungs (*p', p''*) through the pulmonary arteries (*e*) to be aerated, and, returning from thence by the pulmonary veins (*f, f'*), it is poured into the left auricle (*t*), and through it into the left ventricle, to pass again in the same round. There are thus two circulations, the lesser or pulmonic, in which the blood traverses successively the right auricle, right ventricle, pulmonary artery, lung capillaries, and pulmonary veins; and the

greater or systemic, traversing the left auricle, left ventricle, arteries, capillaries, and veins.

The vessels of the greater circulation are fourfold:—1, Those carrying oxygenated blood to the tissues = *arteries*; 2, *capillaries*; 3, those returning to the heart the intravascular, impure blood, rich in carbon dioxide = *veins*; and 4, those collecting and returning the extravasated plasma and fluids from the tissues = *lymphatics*.

50. ARTERIES are firm, elastic tubes, whose walls consist of the following coats:—1, A thin, irregular *endothelium* (fig. 135, *a*). 2, A sub-endothelial *tunica intima* of structureless ground-substance containing small branched connective cells, and a few elastic fibres (in the smaller vessels). 3, A *fenestrated* or *lamellar elastic coat*, in which connective cells are embedded. In large arteries this consists of several layers, between which a few longitudinal unstripped muscular fibres are scattered (*b*). These layers taken together are often called the *inner coat*.

4, A thick, stratified lamella, the so-called *middle coat* (*c*), consisting, in smaller arteries, of transverse unstripped muscle cells, placed either circularly, or (in very small vessels) in alternate or spiral series; in arteries of a middle size the thick layer of circular, unstripped muscle is mixed with a variable quantity of connective tissue and elastic fibres. In general, as arteries diminish in size, the proportion of muscular tissue in the middle coat increases; and as they enlarge, the elastic tissue increases. 5, Outside the muscular layer in middle-sized arteries is an *external elastic lamina*, also of fenestrated tissue.

6, The outermost or *adventitious coat* consists of layers of felted fibrillar tissue with elastic fibres, derived from the condensation of the surrounding tissues (*d*). In the larger vessels, and in unsupported arteries such as those of the abdomen and face there are bundles of longitudinal muscular fibres in this coat.

In very large arteries the middle coat consists of 10 to 40 lamellæ of fenestrated elastic tissue, bound together by connective tissue, the intervening meshes being filled by homogeneous ground-substance, fibrillar connective tissue, and a few transversely placed muscle cells. The outer and inner elastic laminae are generally very thick in vessels of large size.

The arrangement of the muscular coat varies in different vessels. It is absent in the ascending aorta, the pulmonary artery, the retinal and Haversian arteries. The arteries entering muscles have a circular set only; the larger visceral arteries—the cœliac, mesenteric, renal, hepatic, and spermatic—have an internal longitudinal and an outer circular set of muscle cells; while the larger limb arteries have an outer and inner circular, and a middle longitudinal set. The umbilicals in the fetus have outer and inner longitudinal, and an intermediate circular series of fibres; but this is not the case in the internal iliac.

The amount of muscle and elastic tissue in the arterial wall varies with the position as well as with the size of the vessel. The carotids and axillaries have much more elastic tissue in their walls than the cœliac and femorals, which have a thicker muscular coat.

The arterial system branches, tree-like, from the aorta or main artery as a trunk. The sectional area of the aorta at its origin is 616 sq. mm. The combined area of the 56 branches arising from it is 1055 sq. mm.; that of the secondary branches of these is greater still; and, finally, that of the capillaries is 780 times greater. The whole arterial tree, therefore, expands in calibre from the aorta to the smallest branches. This expansion is departed from in a few instances, thus the combined sectional areas of the two common iliaes is practically equal to, sometimes a little less than that of the aorta.

Each artery has an area of distribution, which it nourishes; and the size of the vessel depends not only on the size, but on the activity of the metabolism in the organ supplied. Thus the splenic artery has a sectional area of 28 sq. mm., and supplies an organ 195 grammes in weight, while the various vessels supplying the femur have a sectional area of 9.2 sq. mm., and supply an organ which weighs 450 grammes. In general, it may be estimated from the mean of many observations that the arteries of muscle have a sectional area of 1 sq. mm. to every 18 ccm.; compact bone has 1 sq. mm. for each 25 ccm.; and the spleen 1 sq. mm. for every 5.5 ccm. of volume. In a case of an old ankylosed knee with atrophied muscles, the sectional area of the common iliac artery on the affected side was to that on the sound side as 50:95.

In a few cases, as in the kidneys, retina, and brain, the arteries break up into branches which do not communicate with each other; such vessels are called **end-arteries**, and if these trunks are blocked up, the tissue to which they are distributed dies. In most instances, however, the vessels of neighbouring regions communicate more or less freely with each other, the communications being called **anastomoses**. Of these there are three kinds:—1, *inosculative*, where large arteries running in the same general direction open into each other, as at the base of the brain; 2, *collateral*, where branches arising from the upper part of a stem communicate with other branches arising from the same stem at a lower level; 3, *heterocladic*, where branches derived from separate trunks communicate near the borders of contiguous arterial territories. Anastomoses of the first kind occur in viscera, such as the small intestines or brain, requiring a uniform vascular supply; those of the second class occur in limbs where the motion of a joint is liable to obstruct the circulation in the main artery of the limb, the anastomotic branches arising above and below the level of the joint. In anastomotic arteries of the second and third class, contrary currents flow in the two component arteries, and the blood is driven into the small side branches which are always abundant. In those of the first kind the two currents coalesce and blend into one, flowing in the same direction, hence anastomoses of the former kind are called *open*, of the latter kind, *closed*.

Dilatations of anastomotic trunks with contraction or obliteration of the original main vessel constitute the commonest forms of variation met with among arteries.

The tissues composing the wall of an artery have a wide limit of elasticity, the modulus of dead arterial tissue being 0·0735, that of strips taken lengthwise and crosswise is fairly equal. The coefficient of elasticity, however, increases with increasing pressure. Thus, by increasing the pressure the coefficient of elasticity of the femoral artery can be made to vary from 10,000 to 19,000. Longitudinal strips of aorta 1 cm. in breadth broke with a weight of 6·50 kilos., transverse strips of the same size with a weight of 5·7. Longitudinal strips of carotid of the same width broke with a weight of 4·2, the radial artery broke with a weight of 4 kilos.

The arterial coats are constructed to bear a considerable degree of intravascular tension. Thus, the human carotid will bear without rupture the internal pressure of a column of mercury 1·85 metres in height, or about seven times the ordinary blood pressure. It is interesting to note that the actual thicknesses of the walls of vessels observed are always greater than those calculable on Barlow's formula for pipes, $t = \frac{rP}{c - p}$, where t = thickness, r = radius, c = cohesion, and p the internal pressure. The resistance to the flow is increased by the presence of bends, as in the vertebral and inferior thyroid arteries, by division or by inosculation.

Arteries are sufficiently firm to retain their roundness of outline, and they appear empty after death. As age advances the elasticity of arteries diminishes, and in consequence such vessels as are imperfectly supported are apt to elongate and to become tortuous and spirally twisted. A few vessels, such as the vertebral, are normally spiral, but the temporal, facial, splenic, and iliacs often show senile spirals from loss of elasticity.

Arteries may be divided according to their sizes into classes:—

1. Those of the first class exceed 8 mm. in diameter, such as the innominate, femoral, iliacs, subclavian, and common carotid. These arteries have each one attendant vein.
2. Those of the second class are between 8 and 6 mm. in diameter, and may have one or two attendant veins.
3. Those of the third class are between 6 and 3 mm. in diameter, and usually have two veins accompanying them.
4. Those of the fourth class are below 3 mm., and also usually have two veins.

In general, arteries take the shortest and most protected way from their origin to the territory of distribution, and consequently those of the 1st, 2nd, and 3rd classes are always sub-fascial, and invested by a special envelope of the fascia of the limb as a sheath. They usually lie along the edge of a bone for protection, and are so disposed that they are not compressed by muscular action, which may even cause negative pressure. The main arteries of limbs are on the flexor side, and medial. Where vessels of size larger than the fourth order have to traverse muscles, they are protected by tendinous arches.

Arteries branch in various ways. Sometimes they bifurcate evenly into two equal branches, which in that case diverge at equal angles from the line of the trunk produced. If the branches are unequal, and one is less than half and exceeds two-fifths of the original stem, then the stem artery from which the branch comes off is deflected from its straight course to the opposite side, and the degree of deflection varies with the size of the vessel.

If two equally large vessels arise opposite each other from a central stem, the direction of that stem is not affected.

51. CAPILLARIES are the minute, contractile, and elastic tubules which connect the smallest arteries with the radicles of the veins. They vary in diameter from $12\ \mu$ in red marrow to $5\ \mu$ in the white substance of the brain, and form networks whose meshes generally differ in shape in different tissues (fig. 136), being elliptical in muscle (fig. 117), rounded in gland, polygonal in serous membrane, radiating in the liver, with simple loops in skin, with arched loops in the iris. These meshes are close or lax, according as the tissues they traverse are more or less metabolic.

Capillaries are lined by a delicate endothelium, whose cells are united by an intercellular cement, marked here and there with fine dots (*stigmata*), which sometimes dilate into seeming apertures (*stomata*). Outside the endothelium is a fine, structureless layer (*perithelium*).

The sizes and closeness of the capillaries in a tissue influence its nutrition. As equal quantities of

blood pass through each plane of the vascular system in a given time, and as the velocity varies inversely with the lumina of the tubes while the resistance increases with increased area of wall, so the rate of flow of blood in the capillaries is much slower than that in the large arteries. The sectional area of the capillaries in the body of a well-grown adult has been estimated at 3,000 sq. cm.

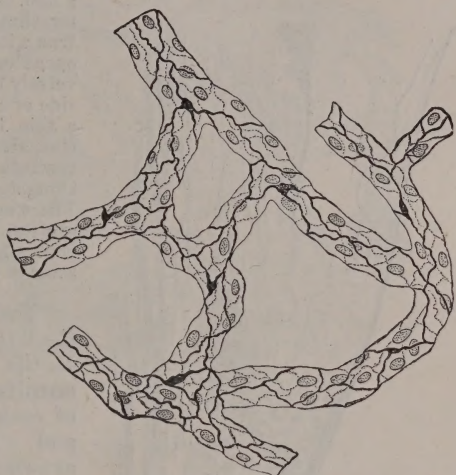


Fig. 136.—Capillaries.

52. VEINS are larger in calibre, less uniform in structure, and thinner in coats than arteries. The venous wall consists of (1) an *inner tunic* made up of an *endothelial lining* (fig. 137, *a*), whose cells appear shorter and broader than those in arteries, but this may be due to the different conditions of tension of the walls, and a *sub-endothelial striated layer* of fine connective tissue, often containing a fenestrated elastic lamina and muscle cells (*b*). (2) A *middle coat*, consisting of a thin layer of circularly disposed muscle cells (*c*), embedded in a fibrous basis, sometimes with an underlying longitudinal fibrous layer.

Muscular fibres are absent in the superior vena cava (except close to the auricle), the innominate, jugular, and subclavian veins, in the veins of bones and of the nervous system. In the uterine veins the only muscular fibres are longitudinal. In the inferior vena cava, the hepatic, renal, spermatic, azygous, and axillary veins there is an outer longitudinal and an inner circular muscular layer. In the mesenteric and portal veins, and the tributaries of the inferior vena cava, there is a circular layer between an outer and inner longitudinal series, although the coat thus constituted is very thin.

(3) The *outer or adventitious coat* of connective tissue is the thickest, consisting of an inner elastic longitudinal layer and an outer areolar layer (*d*), which contains longitudinal muscle cells in the veins of the inferior caval system.

At definite spots in the walls of veins, folds of the lining layer form **valves** (fig. 138), each of which appears like a pocket, presenting a crescentic attached

border, and a free edge directed towards the heart. They occur in pairs in the course of a vein, but are single at the mouths of branches. The vein is dilated on the cardiac, contracted on the distal side of a valve.

Valves have been described as situated at regular distances which are a n th power of some fundamental interval which varies in each vein with its physical conditions, the interval being 7 mm. for the superficial veins of the lower, and 5.5 for those of the upper extremity, but this is only true within wide limits. A lateral branch generally opens on the proximal side of each valve, and conversely there is generally a pair of valves on the distal side of each branch. Each valve (fig. 137) consists of a thin layer of the inner coat with longitudinally elongated endothelial cells on the side directed towards the centre of the vessel, and transversely elongated cells on the cardiac side of the valve. There are no valves in the large trunks of the portal system, in the coronary, or meningeal veins in general. Valves, however, exist in the gastric and some of the smaller mesenteric veins.



Fig. 137.—Longitudinal section of a vein at the level of a valve.

areolar threads, unstripped muscle (c), and elastic fibrils (a). Tissue of this kind is called **cavernous** or erectile tissue, and is enveloped in a strong fibrous capsule, as in the corpora cavernosa penis.

In the walls of all blood-vessels larger than those of the fourth class are fine vessels (**vasa vasorum**) which pass in a distal direction, and are distributed to the outer and middle coats only. Lymphatics and lymph spaces are abundant in and around the adventitia. Plexuses of nerves ramify in the walls of all vessels.

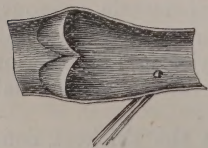


Fig. 138.—Valves in the saphena vein.

In some tissues blood-vessels divide into tufts of minute and frequently communicating vessels, which end in capillaries; these are called **unipolar retia**. In other places vascular trunks divide in like manner, but the branches reunite into larger stems, which again ultimately divide and end in capillaries; these are **bipolar retia**, such as the glomeruli in the kidney.

Some retia are purely arterial; some, as in the liver (fig. 134), are venous; some are mixed.

53. EMBRYOLOGY OF THE VASCULAR SYSTEM.—The vascular system, as has been already described, arises as a subdivision of the coelom, outside and around as well as within the embryonic area (fig. 23). The primitive heart, which is formed by the coalescence from before backwards of the two bilaterally symmetrical ventral tubes of the hæmocœlom (figs. 26, 27, and 28), is of large proportional size, and becomes sigmoidally curved (fig. 28), lying on the ventral side of the fore-gut, to which it is tied by a *mesocardium*, on the postaxial side of the visceral slits; and it is continuous posteriorly with the *sinus venosus* (*sr*). The curvature of the tube is double; viewed sagittally, it appears as a loop, the venous limb of which passes to the left of the arterial; ventrally it appears S-shaped, with an arterial curve concave upwards and to the left, and a venous curve concave downwards. The ventricular loop soon loses its mesocardium, and appears as a stomach-shaped curved bag, widest at its left end.

The mesoblast of the heart tube early differentiates into two layers, an inner or endothelial (fig. 140), which bounds the lumen of the cavities, and an outer, which becomes muscular. The continuous cardiac loop differentiates into three parts—1st, the **primary auricle** (*au*), behind and below; 2nd, the **auricular canal** (*c*); 3rd, the looped **ventricle** (*v*).

Below and behind the auricle, the confluence of the allantoic (fig. 28, *u*) and hypoblastic (*o*) veins, with the somatopleural veins of each side, forms the **sinus venosus** (*sr*); which at its upper part dilates into a sac, applied to the back of the auricle, into which it discharges itself by a single opening (fig. 152). This **sacculus venosus** has two cornua (fig. 152), right and left, which receive the lateral somatopleural veins (duct of Cuvier); of these the right becomes the larger and more vertical, the left the smaller and more horizontal (fig. 142, *d, s*).

The body of the auricle into which the sacculus opens, expands on each side of its mesocardial attachment to the fore-gut into two lateral pouches, the **auricular appendages**. These (fig. 141, *o, o'*) soon exceed the ventricle in transverse width (fig. 141, 5), projecting forwards, right and left of the bulbus aortæ (*b*), which they embrace, their terminal edges becoming lobate and irregular. The wall of the auricle is dense from the first, and the endothelial lining is in contact with the muscle.

The **auricular canal** (figs. 140, *c*; 142, *c*) is a narrow segment, distinguished by having its endothelial lining expanded into two broad lateral, and two narrow sagittal pads (fig. 143, *c*—*auriculo-ventricular pads*), which constrict its lumen to a narrow slit, although the muscular wall, which is very compact, is elliptical in section. This canal is at first vertical, but becomes directed almost horizontally forwards to open into the ventricle.

The **ventricle** forms a horse-shoe-like loop (figs. 22; 140; 141, 2, 3, and 4), whose hinder or left end is the **conus venosus**, and its anterior right end is the **conus arteriosus**. The wall is of spongy consistence, and its trabeculae have an endothelial investment. At first the lower edge of the loop is evenly convex, but a shallow furrow (fig. 142, *f*) soon notches this margin, dividing it into right and left portions, and, corresponding to this, a sickle-like ridge (figs. 142; 143, *v*) rises within the cavity from its fundus, with a free concave margin upwards towards the auricular canal (fig. 145, **SIF**). This **septum inferius** is nearly transverse, passing from the left of the conus arteriosus to the right of the conus venosus; and when it appears, the two ends of the ventricular loop approach and finally cross each other, so that the up-rising conus arteriosus lies in front of the down-directed conus venosus.



Fig. 139.—Erectile tissue.

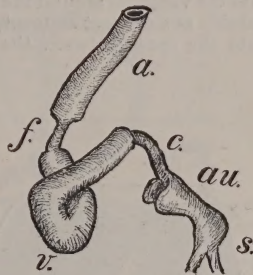


Fig. 140.—Diagram of lining or endothelial layer of primitive heart—*f*, fretum; *a*, aorta.

As growth proceeds, the auricular canal (fig. 143, *c*), which is strongly marked off from the ventricle, becomes projected downwards into it, turning in the mouth of the ventricle along with it (fig. 146, *a*, *l*), thus making a projecting muscular double-layered lip jutting

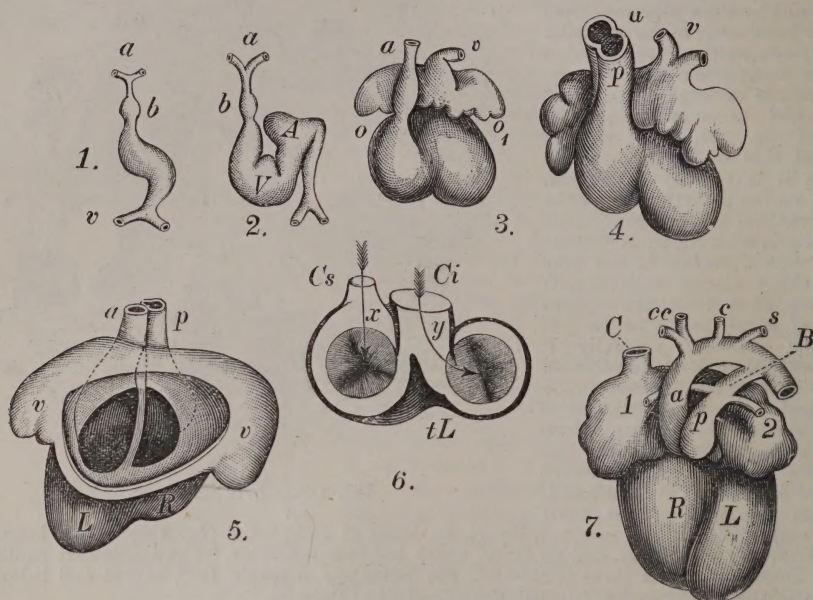


Fig. 141.—Diagram of successive stages of development of the heart.

into the ventricle around the mouth of the auricular canal. The latter ceases to appear on the outside as a distinct segment, and forms an enveloping lip for the auriculo-ventricular opening. Into the space between the involuted auricular canal and the invaginated mouth of the

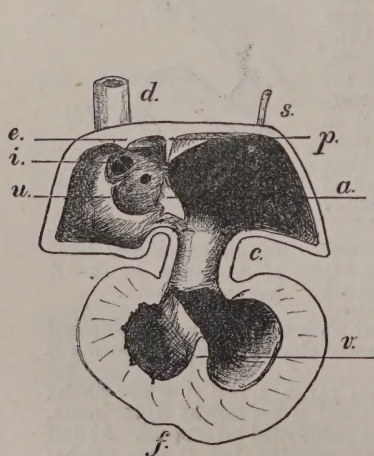


Fig. 142.—Section through embryonic heart, showing auricular canal.

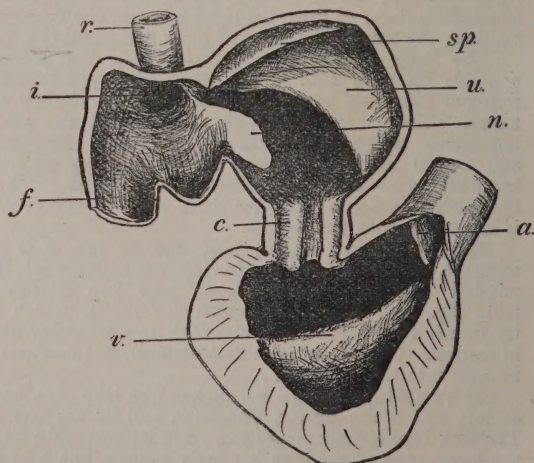


Fig. 143.—Vertical section through embryonic heart at right angles to 142—*sp*, septum spurium.

ventricle, a thick layer of connective tissue (*e*), continuous with the **epicardium** or outer connective envelope of the heart (fig. 146, *e*), becomes interjected, making a fibrous ring around the opening and an intermediate connective stratum in the lip.

The mouth of the conus arteriosus is continued into the first part of the arterial canal (the *fretum*—fig. 140, *f*), which is the most constricted part of the vascular system, and whose endothelial lining is thickened into four projecting pads. The *fretum* communicates

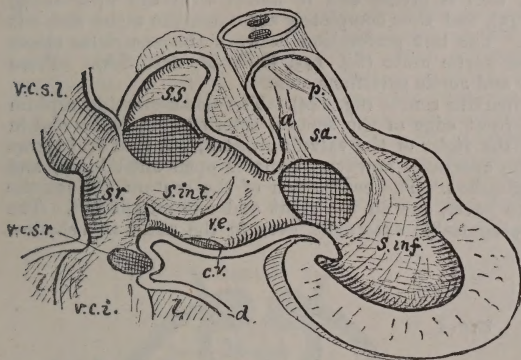


Fig. 144.—Section of developing heart, showing components of septa—*d*, diaphragm.

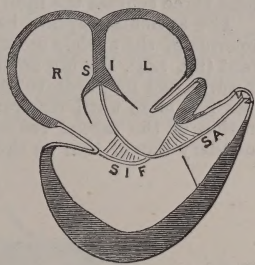


Fig. 145.—Formation of ventricular septum.

with the bulbus aortæ (fig. 140, *a*), which is fixed to the fore-gut by a mesocardial fold and extends into the unleft mesoblast anterior to the coelom. The wall of the bulbus consists of three layers, a lining endothelium, a soft connective middle layer, becoming in the adult the sub-endothelial portion of the *tunica intima*; and a third or muscular layer, which, at its earliest appearance, is continuous with that of the heart.

Completion of the Ventricular Septum.—Along the sides of this bulbus, two longitudinal, semi-cylindrical ridges appear, which project into its lumen and ultimately unite (fig. 144, between *a* and *p*), at first above, afterwards the union extends obliquely downwards; the primarily single aortic bulb thus becomes divided into two vessels, an anterior

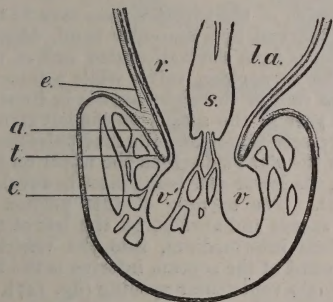


Fig. 146.—Formation of auriculo-ventricular valves.

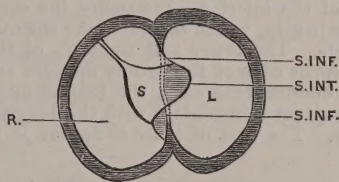


Fig. 147.—Diagram of completion of auricular septum, horizontal view—*S. INT.*, valvula sinistra; *S. INF.*, lower edge of septum superius.

or pulmonic (*p*), and a posterior or aortic (*a*). At first the plane of this *septum aorticum* (figs. 143, *a*; 145, *S.A*) is at right angles to that of the *septum inferius* (fig. 145), but as they grow towards each other, they each become laterally twisted until their planes nearly coincide. In this state the ventricle appears imperfectly divided, and the bulbus is perfectly divided above but imperfectly below.

Completion of the Auricular Septum.—As the heart grows in size, the saccus venosus becomes more closely applied to the back wall of the auricle (fig. 144, *s.r*), the middle line of which, being fixed to the fore-gut, is prevented from expansion (fig. 141, *tl*), and is made to project as a crescentic fold into the interior of the auricular cavity, the *septum superius* (figs. 143, *u*; 144, *s.s*). Eventually the saccus becomes an integral portion of the back wall of the auricle, the two lips which border its communication with the body of the auricle expanding into crescentic folds, that on the right becoming the *greater Eustachian valve* (figs. 144; 148, *v.e*), that on the left, the *valvula sinistra* (fig. 142, *u*; 148, *v.sin*). The lower portion of the boundary wall between the auricle and the saccus projects into the cavity of the auricle as a wedge-shaped mass of connective tissue (figs. 143, *n*; 145, *Sl*;

146, s), which, jutting downwards towards the auriculo-ventricular opening, becomes fused with the fore and hinder auriculo-ventricular pads of the auricular canal, and thus divides the cavity of the auricular canal into two parts. To this down-growing partition the name **septum intermedium** (fig. 144, s. *int.*) is given, and it unites with the up-growing septum inferius of the ventricle (fig. 145), and thus completely separates the right and left ventricles from each other (fig. 134, s). The last perforation between the ventricles closes when the septum inferius and septum aortæ unite (fig. 145, SIF, SI, and SA). From these three sources the interventricular and aortic partitions arise.

The auricular septum has also a tripartite source (fig. 144). The down-growing septum superius of the auricle meets with the front edge of the septum intermedium below and in front (fig. 144), leaving an archway on the right of the valvula sinistra, but that fold grows upwards and forwards to close it. The aperture, however, remains open until birth, and does not close until respiration is established. The completion of the septum divides the portion of the saccus venosus into two parts, one on the right and one on the left. The boundary line of that on the right is recognisable externally even in the adult as a shallow

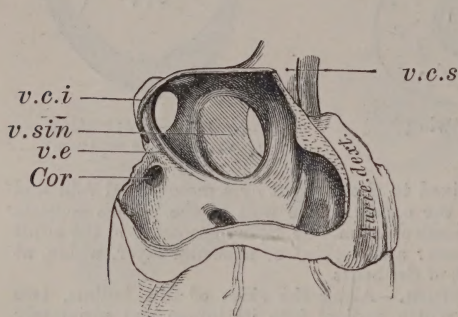


Fig. 148.—Right auricle of fetus.

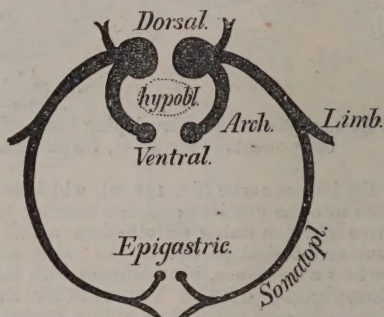


Fig. 149.—Diagram of primitive metameric arterial arch.

suleus terminalis passing from the right of the opening of the superior vena cava to the left of the inferior. Internally the same boundary is marked by a muscular band, **tænia terminalis**, which separates the smooth wall of the saccus from the fasciculated wall of the auricle. The lower and right lip of the opening is the Eustachian valve, while a trace of the upper edge of the saccus appears as a ridge on the roof of the right auricle in front of the superior vena cava, the **tænia sagittalis**. The part of the saccus on the left side of the septum is in contact with the lungs, and receives vessels therefrom, the four pulmonary veins. The first of these to appear is the superior on the right side, then the upper on the left, the lower pair being later in development.

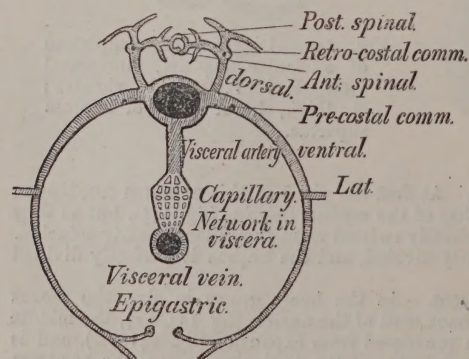


Fig. 150.—Diagram of metameric arcade—a later stage.

When the pulmonary veins increase, they carry with them from the auricle a layer of striped cardiac muscle in their outer layer.

54. THE DEVELOPMENT OF THE ARTERIAL SYSTEM.—

The vascular system of man is a modification of a simpler system of metameric and inter-metameric vessels. The primitive vertebrate vascular system probably consisted of a tubular arcade on the splanchnic wall of each side of each segment (fig. 149), joined to the corresponding arch in the preceding and succeeding segment, by a dorsal and ventral intermetameric trunk

on each side of the middle line. These vessels originally formed a double series, consisting of the two long ventral and two dorsal trunks, and the lateral uniting arch in each segment.

One of the earliest changes which has taken place is the fusion into a single trunk of the

dorsal vessels; this commences behind the head and travels back rapidly, so that very soon there is but one dorsal aorta for the middle and hinder part of the body (fig. 150). In the region of the head and neck, the foremost ends of these vessels remain permanently separated as the *internal carotid arteries* (fig. 151), while the part intervening on each side, between the dorsal aorta and the carotids, becomes obliterated.

There were originally two ventral longitudinal vessels in the hæmocœlom, but their union occurred even earlier than that of the dorsal, as has been seen in tracing the development of the heart. The formation of this organ differentiates the pre- from the post-cardiac portions of the ventral vessel, the former of which, with the dorsal trunk, the pre-cardiac lateral arcades, and the dorsal portions of the metameric vessels in the post-cardiac segments, together with vessels arising from them, constitutes the adult arterial system. As a consequence of the differentiation of the heart, the only metameric arches which remain are pre-cardiac, joining the ventral to the dorsal aorta by vessels which become the successive aortic arches. Behind the heart the dorsal ends of the post-cardiac lateral metameric arcades extend from the dorsal aorta through the mesogastric fold, and end in the splanchnopleure.

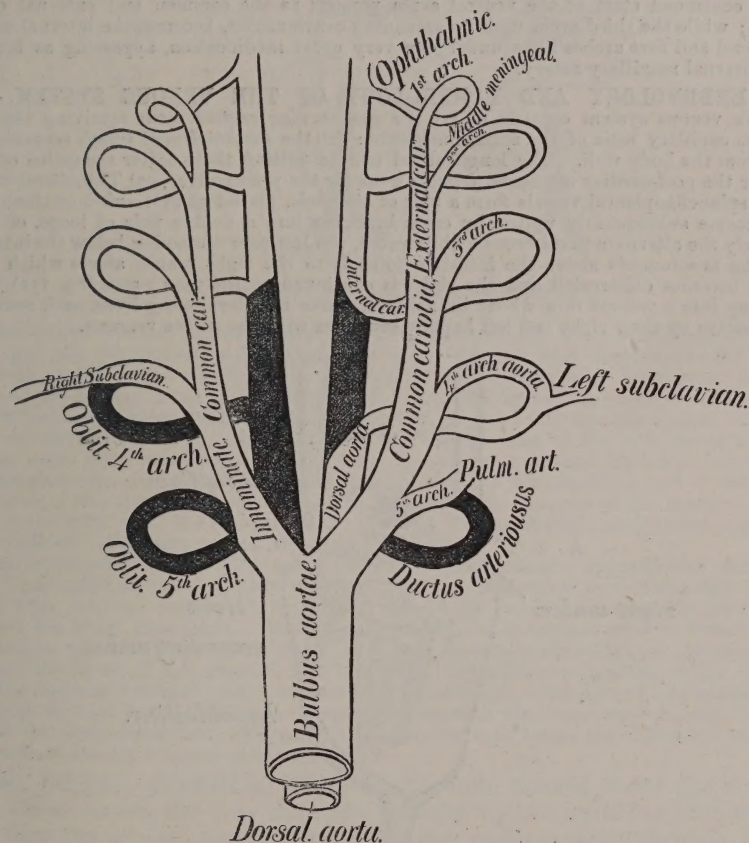


Fig. 151.—Diagram of aortic arches. The parts in black are obliterated in the adult.

These have participated very early in the specialisation of the post-cardiac splanchnopleure and have become visceral arteries, broken into a capillary plexus in the middle of their course (fig. 150), and from this their continuation has become venous, ending in the sub-intestinal visceral vein which is a specialised derivative of the post-cardiac ventral vessel. The modified remains of these vessels form bronchial, œsophageal, celiac, mesenteric, and vitelline arteries, which, though originally paired, have for the most part undergone, like the longitudinal trunks, a fusion into single median vessels.

On the development of the muscle-plates and somatopleure, a parietal branch arises from the dorsal aorta in each metamere for their supply, and when the musculature differentiates

into dorsal and ventral, this gives off corresponding dorsal and ventral branches (fig. 150), distributed to the respective regions of each metamere, the sizes of these vessels being proportional to the sizes of the territories to be supplied, and to the activity of metabolism therein. They are least modified in the dorsal and lumbar regions. From these in the pre-cardiac and pre-caudal regions, the limb-vessels arise.

The pre-cardiac aortic arches are five on each side. The ventral aortic trunk lies medially in the anterior prolongation of the coelom, beyond which it stretches as far as the oral cleft, where it gives off two branches on either side. Still farther back, nearer the heart, three others subsequently arise, each passing into the substance of a visceral arch, and ending posteriorly by joining the dorsal aorta.

Of these arches (fig. 151) the fourth left becomes the permanent aorta, the fourth right forming the arteria innominata and root of the right subclavian. The fifth left arch gives off from its base the two pulmonary arteries to the lungs, and is continued into the dorsal aorta as the ductus arteriosus, which becomes obliterated at birth. The right fifth arch becomes obliterated.

The continued stem of the ventral aorta persists as the common and external carotid arteries; while the third arch, with its ascending continuation, becomes the internal carotid. The second and first arches have undergone very great modification, appearing as branches of the internal maxillary artery.

55. EMBRYOLOGY AND MORPHOLOGY OF THE VENOUS SYSTEM.—The primitive venous system consists of (1) the *post-cardiac ventral stem* receiving the blood from the capillary retia of the splanchnopleure: (2) the *somatopleural vessels* returning the blood from the body wall. The longitudinal trunks uniting these latter are called *cardinal veins* for the post-cardiac segments, *jugular veins* for the pre-cardiac. (3) The *allantoic veins*.

The splanchnopleural vessels form a pair of channels, placed at first sub-intestinally, but these become subsequently united by cross branches into a double pair of loops, of which ultimately the alternate parts become obliterated, the left part remaining below the intestine. Then the anastomosis above the intestine joins it to the right trunk, above which union the left becomes obliterated and the right is continued as the *vena portæ* (fig. 152), which breaks up into a venous rete whose branches traverse the developing liver, and, reuniting, communicate by their right and left hepatic branches with the sacculus venosus.

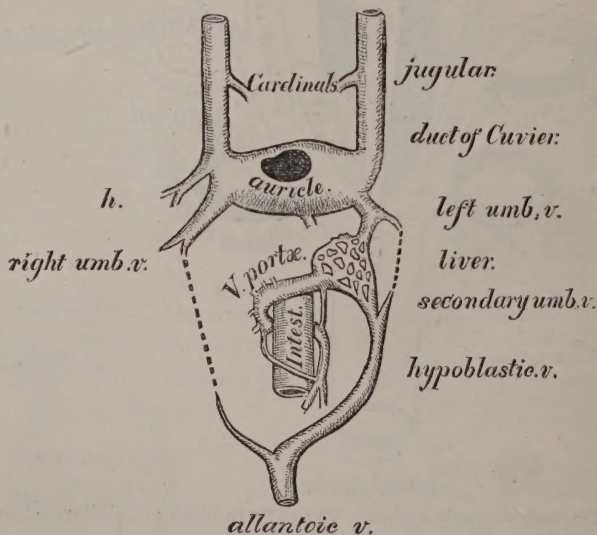


Fig. 152.—Diagram of arrangement of hypoblastic and allantoic veins, as seen from behind. The word auricle is on the sacculus venosus; the hypoblastic vein lies in close contact with the intestine; *h*, veins from heart wall. The words *right* and *left* prefixed to umb. v. should be reversed. The allantoic veins are represented as united below.

The cardinal and jugular veins unite on each side into a single trunk, the duct of Cuvier (fig. 152). These open, one on each side, into the sacculus venosus.

The allantoic veins are two, right and left (fig. 135), which ascend on the ventral wall of the abdomen, and pass above the liver to end in the sinus venosus. Like the

arteries, the veins develop unilaterally. The right allantoic vein is small and soon atrophies, becoming reduced to a small parietal vein. The left umbilical or allantoic vein at a very early period becomes connected by a large secondary umbilical vein below the liver with the splanchnopleural vein, and its upper or supra-hepatic portion atrophies and disappears.

An anastomotic branch from the splanchnopleural to the right hepatic vein subsequently enlarges and forms the *ductus venosus Arantii*, completing the hepatic circle of veins.

The development of the fore-limbs leads to the superaddition of the subclavian veins on each side (fig. 153, *Sub.*), which join the jugulars (*Jug.*), the combined trunks being called the right and left superior venæ cavæ; and as the unilateral displacement of the saccus

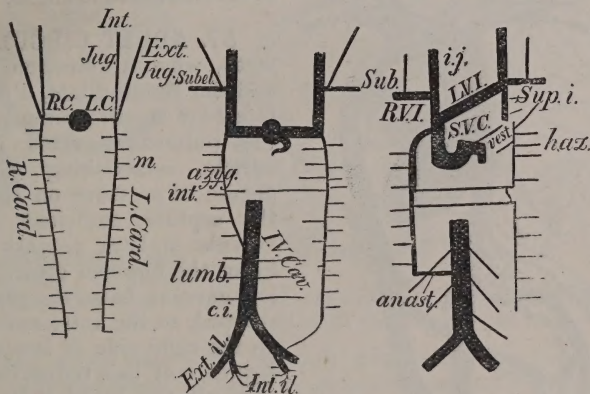


Fig. 153.—Development of the systemic veins.

venosus places the left superior vena cava at a disadvantage, a cross anastomotic channel from the left jugular-subclavian confluence forms the *left vena innominata* (*L.V.I.*), and the vein on the right side becomes subdivided into a *right vena innominata* above the point of union, and a *superior vena cava* (*S.V.C.*), this name being now restricted to the portion below the union. The thoracic portion of the cardinal veins diminishes, that of the right for the most part persisting as the *vena azygos*, that of the left becoming broken up, its upper part remaining as the superior intercostal vein, and its lower becoming the hemiazygos vein. The right Cuvierian duct becomes the infra-cardinal part of the superior vena cava, while the left atrophies, and its remains form the axis of the *vestigial fold*, the oblique auricular vein, the coronary sinus (fig. 148, *Cor.*), and other rudimental appearances on the left side of the heart to be afterwards described.

The development of the lower extremities introduces two new appendicular veins, which ascend and unite on the right side with the inferior or abdominal part of the right cardinal, which thus becomes enormously enlarged, and which passing between the two kidneys receives the blood from them. At the upper part of the abdominal cavity a branch of communication, which forms a short cut to the sinus venosus behind the liver, becomes dilated to carry the blood of this channel into the heart, while the continuation of the abdominal into the thoracic cardinal vein diminishes to a rudiment. The dilated abdominal part of the right cardinal together with the communication with the sinus venosus, and the hinder part of the sinus itself form in the adult the inferior vena cava; the abdominal end of the left cardinal usually becomes obliterated.

56. FETAL CIRCULATION.—In the fully formed fœtus the stream of pure blood enters the body from the placenta by the umbilical (left allantoic) vein (fig. 154, *a*) and ascends into the liver, passing partly through the rete mirabile in that organ (*f*), partly by the ductus venosus (*b*) into the upper part of the inferior vena cava (fig. 141, *Ci*), and thence into the saccular part of the right auricle. Thence it passes through the foramen ovale (the interval between the valvula sinistra and the septum superius) into the left auricle, thence into the left ventricle, and through it into the aorta, and to the vessels of the head, neck, and upper extremities. The blood returning from thence by the superior vena cava (fig. 141, *Cs*), enters the right auricle, and traverses it to pass through the auriculo-ventricular opening into the right ventricle. Thence, ascending by the pulmonary artery, it passes through the ductus arteriosus (fig. 154, *c*) into

the aorta below the arch, and mixing with part of the blood from the left auricle supplies the lower portion of the body, a large part being conveyed by the two allantoic branches of the internal iliac artery (*d*) back to the placenta. Two currents thus traverse the two parts of the right auricle, the first ascends in the saccular portion, the second descends in the arterial portion, but the degree of intermixture is slight, if any.



Fig. 154.—Diagram of the foetal circulation.

of the adult circulation is established (fig. 134).

57. ADULT CIRCULATION.—At birth, when respiration is established and the lungs dilate, a large stream of blood for the first time passes through the pulmonary veins into the left auricle, establishing a considerable degree of pressure on the left side of the septum, sufficient to press the valvula sinistra against the opposite lip of the foramen ovale. The ascending current from the placenta is also stopped, so the intra-auricular tension on the right side is lessened. In consequence of this redistribution of pressure all the blood now entering the right auricle passes through the auriculo-ventricular opening into the right ventricle; and, as the respiratory movement now established creates during inspiration a pulmonic negative pressure, this blood finds its way through the pulmonary artery into the lungs, in consequence of which the ductus arteriosus becomes, like the foramen ovale, closed. The allantoic vessels, whose occupation is gone, likewise become obliterated, and the course

58. THE LYMPHATIC SYSTEM.—The lymphatic vessels are those which collect and return into the circulation the extravasated fluids poured out for nutrition, together with some of the derivatives of tissue-waste. These fluids are at first contained in the lymph paths (fig. 133) around the connective tissue cells, and pass thence into the fine lymphatic vessels (*a*) which are formed by the confluence of these paths, and which are lined by flattened endothelial cells with zigzag margins (fig. 133, *e*). These vessels communicate freely with each other in a plexiform manner, and by their coalescence form larger trunks. They ascend in the interspaces where there is least pressure, usually along the deep blood-vessels, or with the superficial veins, or, in brain and bone, as perivascular sheaths, either outside the coats of the vessel (*space of His*), or irregular endothelium-lined cavities excavated in the adventitia of the arteries (*space of Robin*, fig. 156). Each of the larger lymphatic vessels consists of three coats, like those of a blood-vessel, an outer or adventitia, a middle or muscular, and an inner of elastic tissue, lined by endothelium. These vessels are very irregular in calibre, and their lining membrane presents numerous and closely-set irregularities, ring-like constrictions, projections, folds, or

pouched valves like those of veins. In the larger tubes these follow each other at short intervals, so that injected lymphatics look like strings of beads. The chief communications of lymphatics with veins are at the junctions of

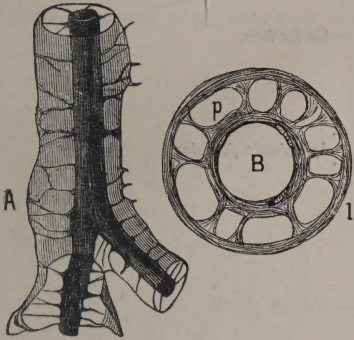


Fig. 155.—Perivascular lymph canal—A, aorta of tortoise; B, artery from brain, showing the space of His.

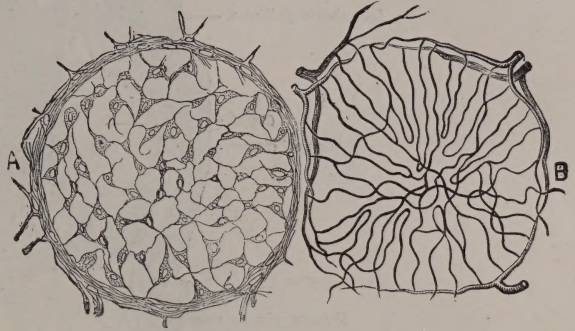


Fig. 156.—Lymph follicles—A, showing adenoid reticulum $\times 350$; B, showing injected blood-vessels $\times 75$.

the jugular and subclavian veins on each side, but a few communications of smaller size occur elsewhere, as into the internal iliac and posterior tibial veins.

Lymph Sinuses.—Here and there lymphatic vessels are dilated into saccular cavities; these are mostly small, the largest being the great abdominal *receptaculum chyli* (§ 294).

Lymphatic Follicles.—In the sub-epithelial tissue along the digestive canal are many patches of adenoid connective tissue (fig. 156, A), in whose meshes numerous lymph corpuscles are entangled, and undergo proliferation.

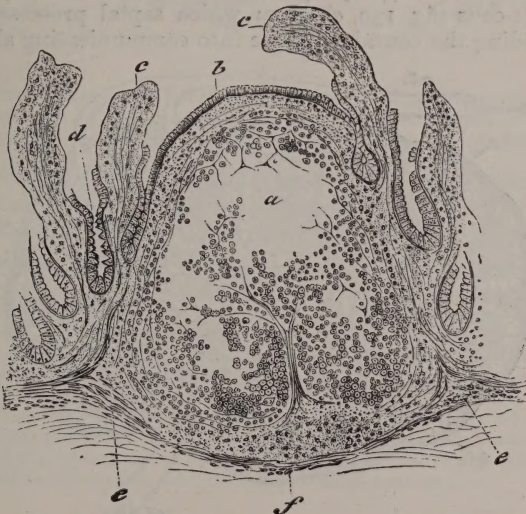


Fig. 157.—Solitary follicle of human small intestine—*a*, cavity of follicle; *b*, intestinal epithelium; *c*, villi; *d*, mucous follicle of Lieberkühn; *e*, muscularis mucosae; *f*, sub-mucous tissue.

The lymph paths of the tissue enclosing them freely communicate with the neighbouring lymphatic vessels. These patches are called lymphatic follicles.

They are of four kinds:—(1) *Diffused* with undefinable limits; (2) definite patches of minute size, abundant in the ileum and colon, and called *solitary follicles* (fig. 157); (3) groups of follicles like the last, closely packed together so as to form a distinct patch; these are most abundant in the ileum, and are called *Peyer's glands*; (4) more clearly isolated patches

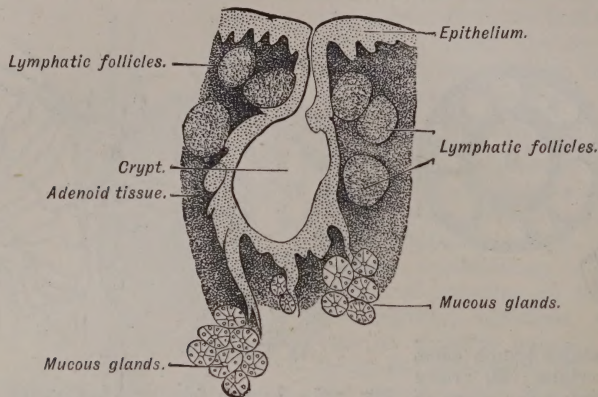


Fig. 158.—Crypt from back of tongue, with cluster of lymphatic follicles.

of adenoid tissue, within a denser areolar tissue capsule, placed at the bottom of small pouches of mucous membrane (fig. 158). These occur either scattered, as on the tongue, or clustered, as in the *tonsil*.

Lymphatic Glands are oval or rounded aggregates of definitely encapsulated follicles, found in the course of large lymphatic trunks and not connected with mucous surfaces. They are variable in size, measurable by millimetres or centimetres, greyish-pink in colour, and dense in consistence. Each is surrounded by a many-layered connective tissue capsule, containing unstriped muscle-cells (fig. 159, *c*), from which septal processes are continued inwards, subdividing the contained space into communicating alveoli, which are

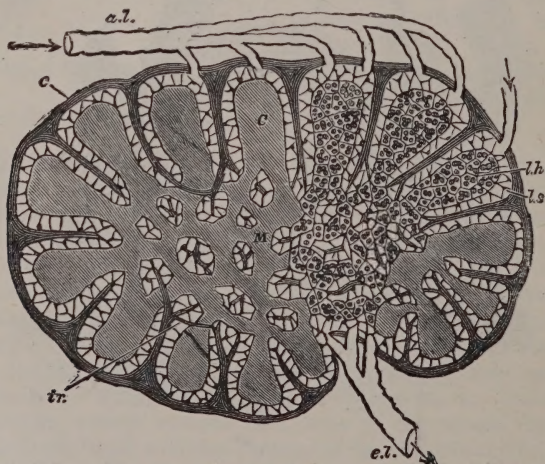


Fig. 159.—Scheme of a lymphatic gland.

so many lymphatic follicles. These septal processes are generally condensed at some one spot, and there become attached to the surface, forming a *hilum*. Within this capsule is a spongy *medullary mass* of reticular tissue (*M*), which

projects into each alveolus as a club-like process (*c*), united to the capsule and septa by numerous filaments (*tr*) which traverse the lymph paths (*l.s*) that intervene between the medullary mass and the capsule, and which are clothed with a layer of adenoid tissue in whose meshes are many leucocytes (*l.h*). With this lymph path the many afferent lymphatics (*a.l*) which enter the gland com-

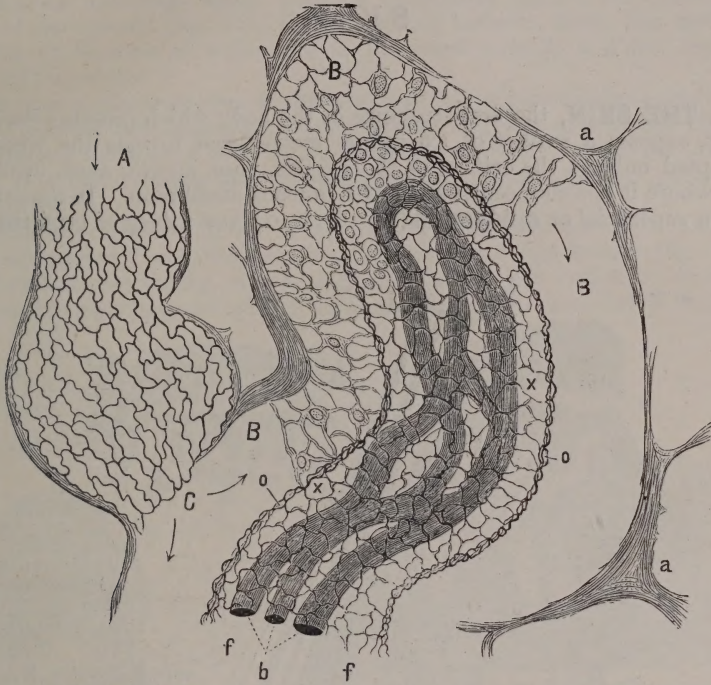


Fig. 160.—Diagram of portion of lymphatic gland, more highly magnified—A, vas afferens; B, lymph space; a, trabeculae; f, process of medullary mass covered with adenoid tissue, x; o, condensed layer separating adenoid tissue from lymph path; b, blood-vessels.

municate, and from it the fewer *vasa efferentia* emerge at the other end (*e.l*). The tissue of the septa and the medullary processes contain many minute arteries and blood capillaries.

Lymphatic glands are found wherever numerous lymphatics converge, or where the lymph current is apt to be temporarily arrested by the motions of parts. They are small in the less vascular and more remote parts, becoming larger in the more vascular and more central regions. The meshes of the lymph paths are very narrow, so foreign particles which may have entered the peripheral lymph paths and through them the lymph canals are usually arrested in the glands, hence the glands at the root of the lung in those who live in a smoky atmosphere are always black. Lymph corpuscles are more abundant in the *vasa efferentia* than in the *vasa afferentia*. Lymphatic glands are more directly connected with the lymphatics of viscera and mucous surfaces than with those of parenchymatous or solid organs.

The structure of the spleen, which stands in close functional relationship to the lymphatic system, is described in connection with its topographical anatomy.

SKIN.

59. THE SKIN, the first structure in the body which presents itself to the student, exposes a surface of 1·6 square metres, and invests the whole body, interrupted only at the orifices of the eyelids, nose, mouth, anus, urethra, and vulva, where it becomes continuous with mucous membrane. It consists of two layers, a superficial or **epidermis** (fig. 161, b, d), and a deep or **corium** (C).

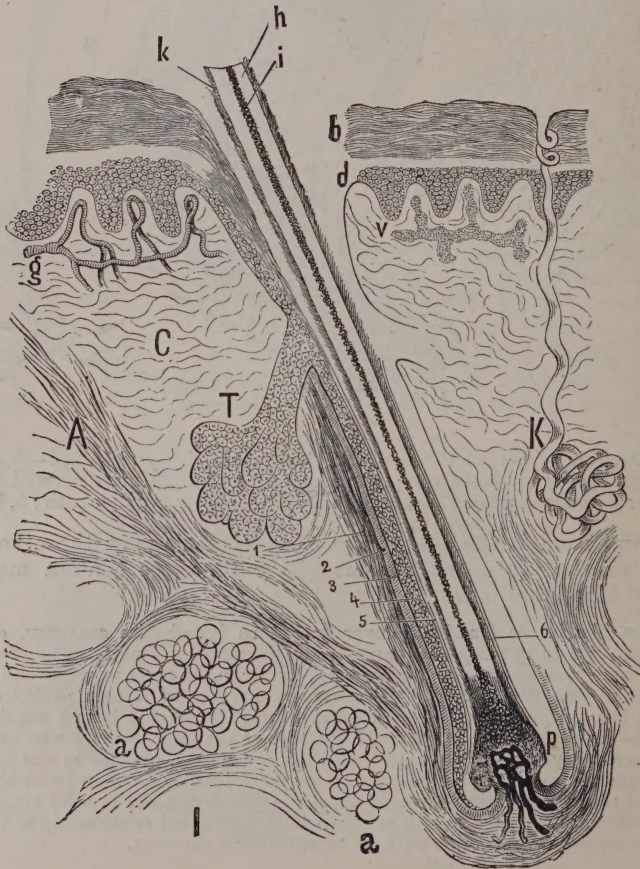


Fig. 161.—Section of skin, with hair follicle and sebaceous and sudoriparous glands.

Epidermis, the lineal descendant of the outer layer of the epiblast, consists of stratified epithelium moulded on the irregular surface of the corium; and varies in thickness, according to the amount of pressure to which it is exposed. It consists of five strata, three of living cells, constituting the *rete mucosum*,

and two of superficial dried cells; these, from deep to superficial, are as follows:—

1. *Stratum columnare*, a layer of columnar prickle cells (fig. 47) moulded on the basement.

2. *Stratum spinosum*, many rows of polyhedral prickle cells around the papillæ of the corium (fig. 162, **R**), containing between them fine nerve filaments (fig. 47, *b*), some of which end in processed cells (*l*), and also containing wandering leucocytes.

3. *Stratum granulosum*, two or three layers of closely-set fusiform prickle cells, with very narrow interspaces, containing numerous granules of eleidin (fig. 47).

4. *Stratum lucidum*, a few layers of flattened horny cells, with indistinct borders, shrivelled nuclei, and semi-transparent walls, staining yellow with picrocarmine.

5. *Stratum corneum*, dried horny scales, whose nuclei have almost or entirely disappeared, and whose surfaces are converted into keratin (fig. 162, **E**). The 4th and 5th layers (fig. 161, *b*) are sometimes called *cuticle* to distinguish them from the 3rd, 2nd, and 1st (*d*), which are called *rete mucosum* or Malpighii.

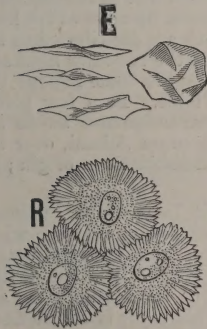


Fig. 162.—**R**, cells of stratum spinosum; **E**, cells of stratum corneum.

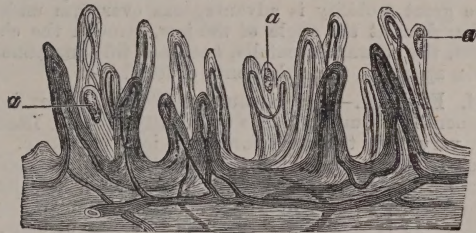


Fig. 163.—Papillæ of corium, with injected vessels and touch corpuscles, *a*.

Epidermis grows by the proliferation of pre-existing cells of the first and second layers, which undergo division, pushing to the surface those which overlie them, which gradually undergo degeneration and dry as they become superficial. If quite destroyed, it is very slowly reproduced; hence the advantage of skin-grafting in promoting the healing of ulcers—i.e., laying on the surface of a bare granulating corium or sub-corial surface fragments of the deep living layer of epidermis containing proliferating cells which act as centres of skin-growth. The process of epidermal cell-development begins early in foetal life, and even before birth superficial effete cells become cast off into the liquor amnii. No vessels enter the epidermis.

In the deeper cells of the stratum spinosum, pigment is developed in certain regions, such as the perineum and around the nipple, or more generally in the dark races. This pigment is probably not originally found in epidermis, but transported thither in wandering pigment cells. The development of eleidin destroys the transparency of skin; hence, where this transformation does not occur, as on the lips, the colour of the vascular corium shines through.

In an adult man surface scales are daily shed to the amount of about 9 grammes.

60. CORIUM (fig. 161, **C**), sometimes called, but incorrectly, true skin, consists of condensed areolar tissue, dense almost to homogeneity superficially, but becoming gradually laxer, with widening meshes, until it merges without any constant plane of demarcation into the subjacent connective tissue; its white fibres decreasing in numbers, until finally its substance becomes soft and fleecy, with its meshes filled with fat. In taking off the skin, this loose tissue is divided at the line where cohesion has become sufficiently slight to allow of its

being stretched; and the layer removed is that whose felting is so close that it appears as a single sheet.

Corium is arbitrarily divided into two layers, a superficial or **stratum papillare**, and a deeper or **stratum reticulare**. The former is the denser, in which the component bundles of fibres break up into their fibrils, which are felted together, with flattened connective cells in their interspaces. The surface of this layer is beset with papillæ, which are cylindroidal processes from .04 to .2 in length, simple or branched—either small, few, and scattered—or large and regular, especially where the epidermis is thick. In each papilla are looped vessels; in many of them are nerve endings of some sort, such as touch corpuscles, &c. (fig. 163).

On the surface of the corium is a fine homogeneous basement layer, not always easy to demonstrate. The stratum reticulare is looser, enclosing small round masses of fat (fig. 161, a) in most places, giving to its deep surface when removed the aspect from which it is named, and its meshes gradually shade into those of the subcutaneous tissue. In this layer, smooth muscle cells exist in the perineum, prepuce, and a few other spots; through it many vessels pass to form a rich network of loops in the papillary layer (fig. 161, g). Lymphatics are abundant in the corium, beginning as intercellular spaces, which become simple channels lined with endothelium (fig. 161, v). There is a superficial finer plexus of lymphatics in the papillary layer, and a deeper larger plexus in the reticular layer, consisting of vessels, many of which have valves. Nerves traverse the reticular layer, dividing into fibrils, which are distributed to the papillæ and epithelium beyond (fig. 47, n). Leucocytes also wander in the reticular meshes.

The skin is usually tied by loose tissue to the subjacent parts, but in some regions the connection is closer, and the skin is then disposed in permanent folds. In a few places where great mobility is advantageous over firm underlying parts, subcutaneous bursæ are developed, as at the angle of the jaw, beneath the chin, over the pomum Adami, over the sacrum, the olecranon, patella, heel, and fifth metatarsal. Cutis is mesoblastic in origin; its papillæ appear in the fifth month of fetal life.

61. FASCIA.—The stratum reticulare shades into a subjacent looser layer, wherein fat generally abounds; this is called **superficial fascia**, and is continuous over the whole body, varying in texture according to local condition. In it the cutaneous nerves and vessels branch before piercing the skin for their final distribution. The deepest portion of this tissue becomes suddenly condensed, laminated, loses its fat and most of its elastic tissue, and becomes white and fibrillar as it invests the underlying muscles. This layer is called **deep fascia**. It is attached to prominent crests of bone, sends processes of its own substance between muscles as intermuscular septa (fig. 129, f), and is generally moulded by pressure so as to form a close envelope of the deeper parts. As the planes of this tissue direct the course of exudations and cover vessels, they are of great importance in Surgery; but there is no primary morphological distinction between this tissue and the superficial fascia. Change of condition, such as the growth of a tumour, can make the laxest of superficial fascia become as firm as the normal fascia lata of the thigh.

62. HAIRS grow upon a large portion of the body surface—the palms, the soles, the red lips, glans penis, prepuce, and nipples being the only hairless regions. Each hair consists of a cylindrical growth of epidermis (fig. 161, h) from the summit of a papilla (p) sunk into a follicle, and each is made up of a **shaft**, or free part, and a **bulb**, which is the part rooted in the **hair follicle**. The shaft consists of an outer layer of imbricated scales (fig. 161, k), which are dried cells whose nuclei are destroyed, covering a cortical layer (fig. 161, h) which can be split up into its component longitudinally-elongated cells, with rod-like nuclei and containing pigment granules, and often air spaces. Within this, in large hairs, is a medulla (fig. 161, i) of rounder or irregular cells, which are not pigmented. The bulb is embedded in a follicle whose wall consists of (1) a condensed layer of the stratum reticulare of the cutis, with longitudinal fibres and connective cells (fig. 164, a) lying upon (2) a modified extension of the papillary layer, with transverse, flattened, connective cells and a few unstriped fibres (c); (3) a homogeneous basement layer internally (d)—within these lie the extensions of the epidermal layer; (4) the continuation of the rete mucosum, forming the external root-sheath of soft, opaque cells (e); (5) the inner root-sheath or continuation of the stratum corneum, which in the middle

of the follicle is laminated, divided into an outer, fenestrated, non-nucleated layer of flattened cells (*Henle's*) (*f*), a middle of polygonal nucleated cells (*Huxley's*) (*g*), and an inner or cuticle of the root-sheath (*h*).

At the bottom of each follicle is a vascular dermal papilla (fig. 165, *c*), on whose summit sits the base of the hair-bulb whose tissue is continuous at each side with the epidermal elements of the root-sheath, which here are not distinctly laminated. Lamination is also obscure at the neck of the follicle, beyond which layers 2, 3, 5, and 6 are not traceable as separate lamellæ.

Into the dermal wall of the follicle passes a band of smooth muscle (fig. 161, *A*), the *erector pili*, which arises from the cutis near the follicle. Every hair follicle is placed obliquely to the surface, and each erector pili lies on the side of the follicle, which makes an obtuse angle with the surface. These by their contraction can make the hairs move and the whole follicle to rise as a papilla, as in the condition of *goose skin* produced by the sudden application of cold. In the angle between each muscle and its follicle lies an acinous fat-secreting gland or **sebaceous follicle** (fig. 161, *T*).

Each hair is firm, hard, and hygroscopic. A head hair can bear without rupture a weight of 60 grammes; a beard hair 72 grammes. When weighted, it can be stretched for 30 per cent. of its length, and will resile 12 per cent. Hairs are not easily decomposed or destroyed by maceration. Dry hair is a bad conductor of heat and electricity, and hence it crackles when being combed in a dry or frosty atmosphere.

The follicles dip for depths varying with the strength of the hair, and their direction is constant in each part of the body. The hairs have, therefore, a definite direction in each part. The local peculiarities of pelage will be considered with each region. There are over one-third of a million of hairs on the surface of the human skin.

Hairs appear in the fœtus during the third month as dark points of thickened epidermis, projecting inwards into the corium, which they indent (fig. 166, *B*), forming embryonic follicles, and becoming surrounded by a homogeneous dermal sheath (*D*, *F*); into the bottom of this embryonic follicle a papilla of the corium rises and projects. The long cells clothing the apex of this papilla (*HK*) become consolidated into a conical cap, which burrows to the surface through the superficial cuticle as the young hair. The hair clothing is well developed over most of the body by the end of the seventh month. These fœtal hairs (lanugo) are shed soon after birth, and replaced by the permanent pelage. A hair generally lives two to four years. When each hair attains a definite growth it becomes freed from the summit of the papilla (fig. 165, *l*) but retains its connection with the root-sheath (*k*). In this condition it may continue for a considerable time; but often a new hair (*h*) grows on the summit of the old papilla, and emerges beside the old one, or displaces it. Not uncommonly a second papilla grows in the old follicle, causing atrophy of the first papilla.

Sebaceous Glands are simple acinous glands opening singly or in pairs into the funnel-shaped mouth of each hair follicle (figs. 161, *T*; 167, *e*). Occasionally, when the lanugo is shed, the gland persists while the hair follicle atrophies, leaving in the adult a gland without a hair. They vary in size and complexity in different regions, and sometimes become specialised as in the mammary gland. Over the whole surface there are over 650,000 sebaceous glands.

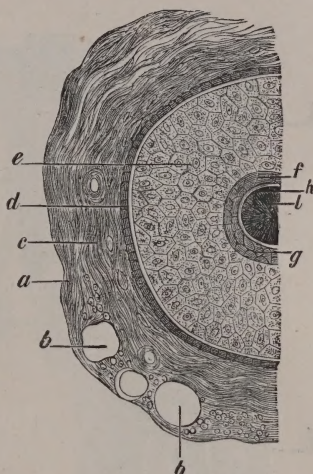


Fig. 164.—Transverse section of a hair (*l*) in its follicle; *b*, blood-vessels.

Sudoriparous or Sweat Glands are tubular follicles, beginning as a blind tube, which is coiled into a round glomerulus, and from which a duct passes to the surface; this duct is straight where it passes through the corium,

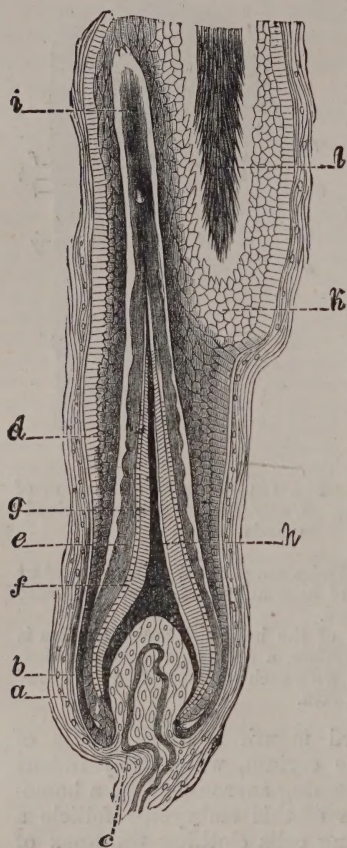


Fig. 165.—Young hair replacing an older; layers are as in fig. 164.

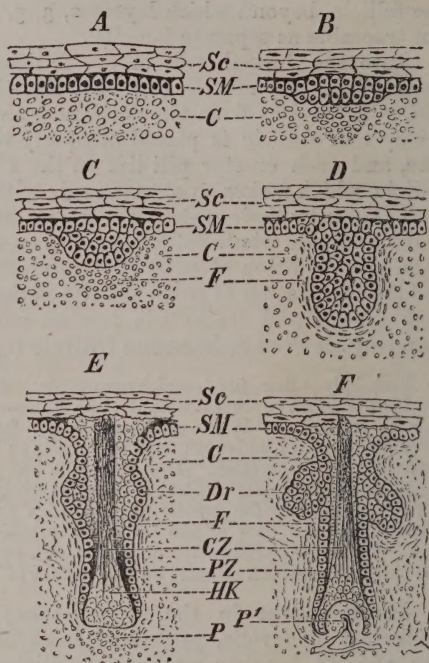


Fig. 166.—Stages of development of a hair—*Sc*, stratum corneum; *SM*, stratum mucosum; *C*, cutis; *CZ*, cells of young hair; *Dr*, developing sebaceous gland.

but spiral as it traverses the epidermis (fig. 161, *k*). In its coiled part the tube is wide, with a lining composed of one layer of radially striated cylinder or pyriform gland-epithelium, covered by an investment of smooth muscle lying superficial to the basement layer, and possibly epiblastic in origin. The duct portions of the tube are lined by two or three layers of flattish epithelium, the innermost layers of which have a distinct cuticular surface towards the lumen. Each duct always passes between the papillæ, and is deprived of proper walls in its epidermal portion, opening by a funnel-shaped mouth (fig. 154, *b*). Sweat glands are absent on the glans penis, prepuce, and prolabium; but they are present elsewhere. In the skin of an adult man it is estimated that there are two and a half millions of these glands, having an estimated secreting surface of 1,080 square metres. A dense arterial plexus surrounds each glomerulus.

Sweat glands appear in the fifth month of fetal life as club-like processes of epidermis (*e*), dipping into the corium, and becoming bent at their extremity.

A lumen develops in the coiled portion (*d*) before any appearance of a duct canal (*e, f*) can be seen.

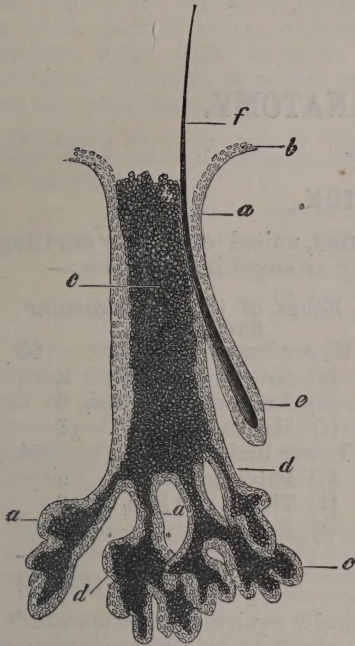


Fig. 167.—Branched sebaceous gland with fine hair, *f*; *a b*, epithelium; *c*, fatty secretion; *d*, acini.

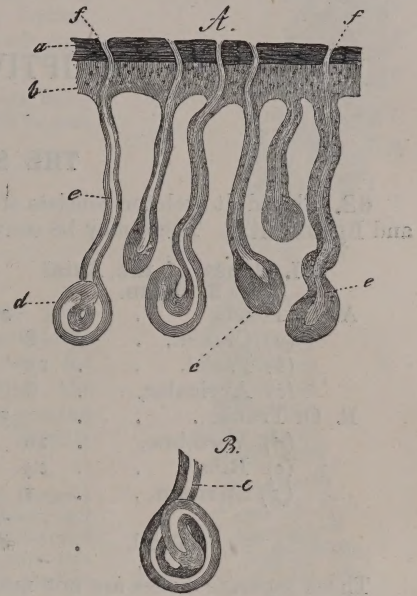


Fig. 168.—Development of sweat glands —*a*, stratum corneum; *b*, stratum mucosum.

Mucous membrane, which will be examined in connection with the digestive canal, is an internal prolongation of the skin, and, *mutatis mutandis*, is similar in structure.

DESCRIPTIVE ANATOMY.

THE SKELETON.

63. The adult skeleton consists of 214 **bones**, united together by **cartilages** and **ligaments**. These may be conveniently arranged in two series:—

I. Bones of the Axial Skeleton.		II. Bones of the Appendicular Skeleton.	
A. Of Head, . . .	29	C. Upper limbs, . . .	68
(<i>a</i>) Cranial, . . .	8	(<i>g</i>) Shoulder girdles, . . .	4
(<i>b</i>) Facial, . . .	15	(<i>h</i>) Arms and forearms, . . .	6
(<i>c</i>) Auricular, . . .	6	(<i>i</i>) Hands, . . .	58
B. Of Trunk, . . .	51	D. Lower limbs, . . .	66
(<i>d</i>) Vertebrae, . . .	26	(<i>j</i>) Pelvic girdle, . . .	2
(<i>e</i>) Ribs, . . .	24	(<i>k</i>) Thighs and legs, . . .	8
(<i>f</i>) Sternum, . . .	1	(<i>l</i>) Feet, . . .	56
Total, . . .	80	Total, . . .	134

These separate bones are not morphologically equivalent. Some which are single in man represent groups of separate elements in other animals; thus the sphenoid of the human skull is composed of ten, the occipital of four elements, and as these two bones unite into one at twenty-one years of age, so this unit of the mature skull really represents fourteen bones which are separate in the skulls of many lower vertebrates.

The student should always keep the bone whose description he is reading before him, and verify each fact as he reads.

64. **VERTEBRÆ.**—The human spinal column consists of thirty-three vertebrae, the upper twenty-four of which are called *true*, as they remain separate during life; while the lower nine are called *false*, because they become consolidated in the adult into two masses. The four lowest, or caudal vertebrae, are rudimental, and ankylose together to form the **coccyx**, and the five above these unite to form the **sacrum**.

The seven uppermost true vertebrae are **cervical** (fig. 169, *C*), and make the skeleton of the neck; the topmost articulating with the skull above: the twelve succeeding are **dorsal** and bear movable ribs (*ib.*, *D*): the five remaining are called **lumbar** (*ib.*, *L*), the lowest of which articulates below with the sacrum.

Each vertebra consists of a **body**, **arch**, and **processes**. The body (fig. 170, 1) is a disc of cancellous bone, whose upper and lower surfaces are joined to its predecessor and successor by soft intervertebral fibro-cartilage (fig. 172, 3), so that the whole series builds up a flexible column of support for the trunk. Each body is transversely convex and vertically concave in front (fig. 171), but flat or transversely concave behind, where it is pierced by one or two large holes for the exit of vertebral veins.

The cancelli are orthogonal, the vertical or pressure planes being the stronger, and the meshes contain red marrow in young and adolescent bones.

The arch, which consists chiefly of compact bone, is attached to the dorsal surface of each body, and bounds the *spinal foramen* (fig. 170, 8). The whole chain of arches, with their intervening ligaments, make, with the backs of the bodies, the wall of the *spinal* or *neural canal*, which contains the spinal marrow.

The area of this canal varies at different levels, being greatest in the regions of greatest mobility, as will be seen in the subjoined table.

380 sq. mm.	at 2nd Cervical.
290	" 7th Cervical.
115	" 2nd Dorsal.
230	" 6th Dorsal.
320	" 5th Lumbar.
80	" 3rd Sacral.

From the convex surface of the arch nine processes project, whereof five are for the attachment of muscles and ligaments, and four for purposes of articulation. Of the former, the **spinous process** (fig. 170, 3) is single, projecting backwards towards the surface in the middle line.

The column of spinous processes collectively forms a projecting row palpable through the skin of the back, and hence, by synecdoche, the whole backbone is sometimes called the "spine." Each spinous process presents two lateral ridges each ending in a tubercle, and a median ridge ending in a central tuberosity.

Two **transverse processes** for muscular attachments (fig. 170, 2) arise from the arch on each side and project outwards. Internal to these the arch thickens into an *articular mass*, from which four **articular processes** project, two upwards (ib., 4), and two downwards (fig. 171, 8), to join correlative processes of the neighbouring vertebrae. That part of the arch between the spine and articular processes, on each side, is flat and rough-edged, and is called the **lamina**, while that between the articular process and the body is rounded, grooved above and below, and is called the **pedicle**. The spaces between the successive pedicles (fig. 172, 4), bounded by the lower grooves of the pedicles above and the upper grooves of the pedicles below, are called the **intervertebral foramina**. Through these the spinal nerves escape, and the lateral spinal arteries enter the spinal canal. The spaces between the laminae of successive vertebrae are closed by elastic ligaments, for the attachment of which there are rough linear areas on each lamina, above and below. The line of attachment of the arch to the body of each vertebra is the *neuro-central line*.

At the root of the laminae behind the articular processes, there is usually a rough area for muscular

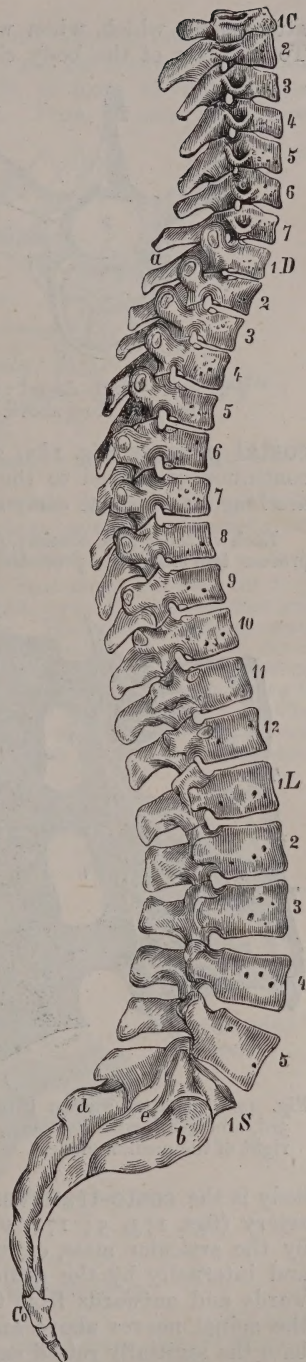


Fig. 169.—Vertebral column, side view.

attachment, which, when well-defined, is named the **tuberosity** (fig. 173, 6). To the side of the body close to the base of the pedicle of each vertebra, a

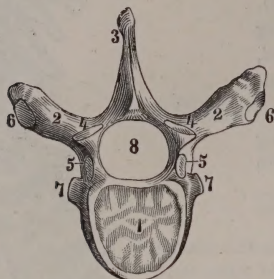


Fig. 170.—Sixth dorsal vertebra, seen from above.

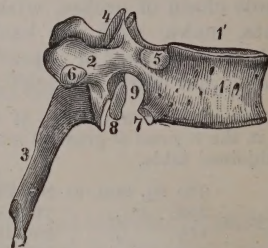


Fig. 171.—Side view of fifth dorsal vertebra.

costal process (fig. 183, 2) is appended on each side. These are small, and continuously ossified to the vertebra, except in the dorsal region, where they are long, and become early segmented off, forming the ribs.

Each vertebra thus consists of sixteen parts—a body, two pedicles, two laminae, a spinous process, two transverse processes, four articulars, two tuberosities, and two costal processes.

The vertebrae of each region present distinctive characters, best marked in the middle vertebrae of the region, while those that join contiguous series become assimilated to their neighbours, and hence are called *passage vertebrae*.

Every vertebra in the column has its distinguishing features, but in each region there are some vertebrae which are strikingly aberrant in form and easily recognisable.

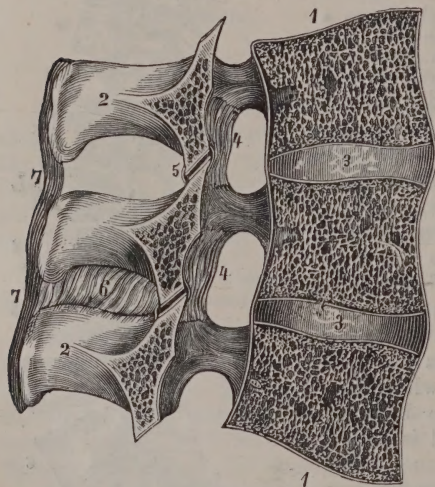


Fig. 172.—Sagittal section through the 2nd, 3rd, and 4th lumbar vertebrae, a little to the right of the median plane.

65. CERVICAL VERTEBRÆ.—

These, although the smallest and densest, have the widest spinal canal (fig. 173). The *bodies* are transversely elongated, and appear transversely concave above, owing to the upward projection of the *neuro-central lip* on the base of the pedicle at each side (fig. 174, *n*). The upper surface has a raised hinder and a depressed anterior lip, but the lower surface is transversely convex and sagittally concave, with a drooping fore-lip. On each side of the

body is the **costo-transverse foramen** for the transmission of the vertebral artery (figs. 173, 5; 174, *v*), bounded in front by the costal process, behind by the articular mass, externally by the costo-transverse lamella (fig. 174, *c.tl*) and internally by the pedicle. The rounded and thick pedicle projects backwards and outwards from the body to the articular mass, deeply notched for the spinal nerves above and below, and bearing along the upper side of its base the sagittally raised *neuro-central lip* (fig. 174, *n*).

The *articular mass* on each side is cylindroidal, with an ovate, flat upper articular surface (fig. 173, 4), directed backwards and upwards, and a lower,

directed downwards and forwards. The *laminae* are narrow, and imbricate each other; the *spine* (*ib.*, 3) is depressed, usually bifid, and the *transverse processes* project outwards from the outer side of the pedicle, in front of the articular mass, and each ends externally in a tubercle (*ib.*, 2). From its anterior surface

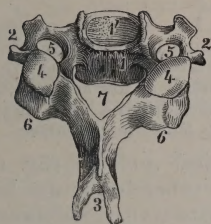


Fig. 173.—Fifth cervical vertebra.

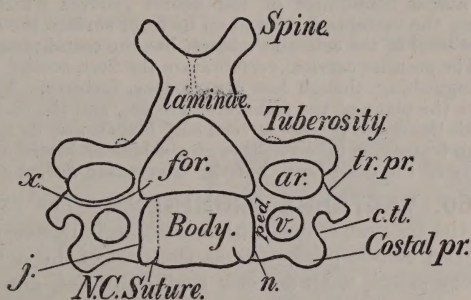


Fig. 174.—Scheme of a cervical vertebra.

a *costo-transverse lamella* (fig. 174, *c.tl.*), concave upwards, projects forwards to join the back of the costal process, closing the costo-transverse foramen externally. The *costal process* is thin, ending externally in a tubercle.

In each cervical body the sagittal is to the transverse diameter of the body as 2 : 3. The posterior surface is vertically longer and on a level a little higher than the anterior, and its two venous holes are separated by a vertical ridge of bone. The anterior surface presents a median flattened ligamentous area, two lateral muscular depressions, and at each side of its lower lip a lateral inferior tubercle. The spinal foramen is heart-shaped, widest between the articular masses, wider on the lower than on the upper aspect of the vertebra, owing to the splay of the laminae, gradually enlarging from the second to the fifth, and diminishing from the fifth to the seventh. The two laminae meet at an angle of about 90° . On the back of the lower part of the articular mass is the *tuberosity* (6), largest on the fifth, rudimentary on the third.

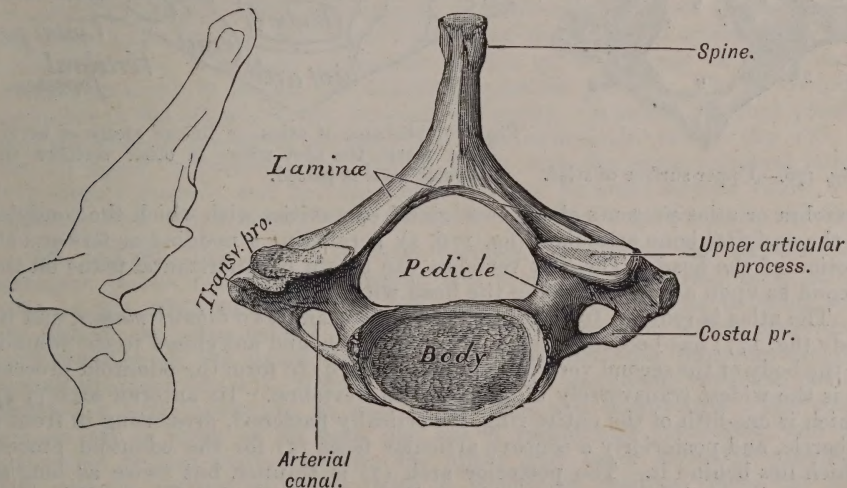


Fig. 175.—Seventh cervical vertebra, top and side views.

The median ridge of the spinous process is very strong on the second, weaker on the others. On each side the diverging lateral ridges are elongated into spurs for muscular and tendinous attachment. Those of the sixth are shortest, though on a longer single base, those of the fifth the most divergent. The costal process starts from the front of the pedicle, external to the neuro-central lip, and its upper border lies on a plane above that of the body. The costal

process of the sixth has the largest tubercle, and as this projects behind the carotid artery, it is called the *carotid tubercle*.

The costo-transverse foramen is small in the seventh, and only contains the accessory vertebral vein, while the vertebral artery traverses the upper six. The transverse processes are sharp-edged above, continuous into the costo-transverse lamellæ below, and they form the hinder boundaries of the neural grooves which pass behind the vertebral arteries. When the vertebra is viewed on its front surface the transverse processes project beyond the outer level of the articular masses, but the costal processes do not.

The peculiar cervical vertebræ are the first, second, and seventh, but each of the others has distinguishing, though less conspicuous, features. Thus in the third the costal tubercle is above the plane of the transverse process, and the costo-transverse lamella is oblique; in the fourth the costal process is vertically longer, and its lower edge is nearly as low as the bottom of the transverse tubercle, though the lamella is still oblique. In the fifth and sixth they are nearly on the same level, but the intervening neural groove is much wider in the latter.

66. VERTEBRA PROMINENS.—The seventh cervical vertebra (fig. 175) has the longest spine, which, although possessing lateral tubercles, is not bifid, and can be felt projecting at the root of the neck. The costo-transverse foramen is very small, with a weak costal process, generally showing only a rudimental tubercle, and giving attachment to no muscle. In rare cases it is large and segmented off, forming a *cervical rib*. The transverse process is large, with an irregular tubercle, and the lower surface of the body occasionally articulates with the first rib.

67. ATLAS.—The first and second vertebræ are modified to allow the head to move as freely as is consistent with the safety of the spinal cord. The first

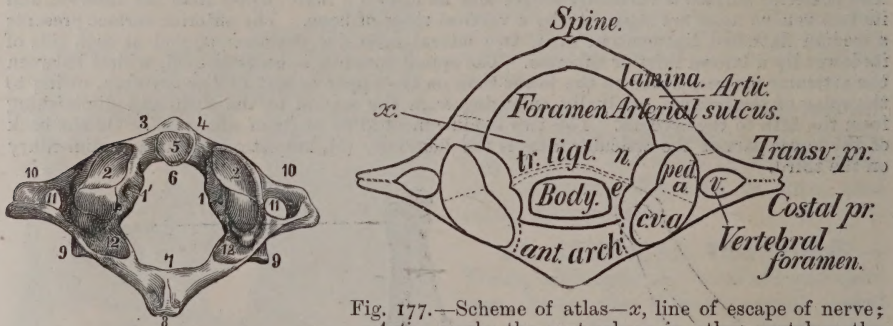


Fig. 176.—Upper surface of atlas.

Fig. 177.—Scheme of atlas—*x*, line of escape of nerve; *Artic.* marks the spot—where in other vertebræ the articular mass is placed.

vertebra or atlas presents above two lateral concavities with which the condyles of the occipital bone articulate (fig. 176, 2), permitting a nodding or fore-and-aft motion of the head. The first vertebra can rotate in a horizontal plane on the second as upon a pivot, carrying the head with it.

The atlas is reduced to a ring of two *arches* and two *lateral masses*; and its body (fig. 177) has become separated from its arch, and ankylosed to the summit of the body of the second vertebra or axis (fig. 179) to form the odontoid process. It is the widest transversely of the cervical vertebræ. Its anterior arch (3-4), which is one-fifth of the entire ring, is vertically flattened, presenting in front a tubercle, and posteriorly a concave articular facet (5) for the odontoid process which lies behind it. The posterior arch (7) is thinner, but twice as long as the anterior, and forms an even parabolic curve, undivided into pedicles and laminae. It bears no spinous process, as any such projection would interfere with its rotation on the axis; but it has instead a rough posterior tubercle (8). The upper surface of this arch is grooved on each side where it joins the articular mass (*sinus atlantis*) for the third stage of the vertebral artery (12).

Each lateral mass presents on its upper surface an irregular articular hollow,

diverging behind from its fellow, with a sharp, raised, outer edge, to receive the occipital condyle (2).

Facing the neural canal on its inner side is an internal tuberosity (1-1') giving attachment to the transverse ligament (fig. 177), which divides the hollow of the ring into two parts—a smaller anterior for the odontoid process (fig. 176, 6), a larger hinder for the spinal marrow (7).

On the lower surface of the lateral mass is an ovoid flat facet for articulation with the axis.

The atlas has no articular processes comparable with those of other vertebræ, as the grooves for the spinal nerves lie behind the lateral mass. Each transverse process starts from the root of the posterior arch, close to the back of the lateral mass, and passes forwards and outwards, jutting out farther than that of any other cervical vertebra, and ending in an obliquely-placed tubercle. The costal process (10) is shorter, with a rudimentary tubercle.

The body of the atlas having slipped from the neuro-central sutures, the dilated bases of the combined costal processes and pedicles are united in front by a pre-central band, the *anterior arch*, which first appears in the embryo as a band of meso-blast, and subsequently becomes cartilaginous and ossifies from a single centre.

The upper articular area is composed of two confluent facets, an *anterior (c.v.a.)* on the inner end of the costal process looking upwards, backwards, and inwards, with a sharp, high anterior lip. The *posterior facet (ped. a.)* is also concave, and looks upwards, inwards, and often a little forwards, having the highest point of its lip posterior and external, at the point of greatest divergence from its fellow.

The internal tuberosity is divided into two parts, an anterior on the base of the costal process to which the conjugal or transverse ligament is attached (*e*); and a posterior (*n*); between these a branch of the vertebral artery and a vein enter the bone. The long transverse process gives leverage to the rotator muscles attached to it, and lies below the mastoid process. The suboccipital nerve lies in the sinus atlantis, beneath the artery, its anterior branch passing over the front of the costal process. The inferior articular surface (fig. 178, 5), like the upper, is preneural (*x*) and in series with the costo-vertebral joints; it is slightly concave, and but for a little knob at its inner surface would, with its fellow, form two symmetrical areas on the surface of a sphere 3 cm. in radius.

68. AXIS.—The second cervical vertebra or *axis* is the thickest and strongest of the bones of this region, and bears the ankylosed body of the atlas as the **odontoid process** (fig. 179). This articulates in front with the arch of the atlas, behind with the transverse ligament, which prevents it from pressing on the spinal marrow. The upper articular processes are preneural, the lower (fig. 178, 7) resemble those of the succeeding vertebræ, but are directed a little outwards, as well as forwards and downwards. The costal process (6) is thick at its base, but has a rudimentary tuberosity, and the transverse process starts between the upper and lower articular processes. The spinous process is strong, with a prominent median ridge, but with depressed and short lateral tubercles.

The tip of the odontoid process (fig. 178, 9) is pointed for the suspensory ligament; below this it is laterally flattened into an oblique surface on each side for the occipito-odontoid ligaments. The atlantic facet occupies the upper two-thirds of the front, that for the transverse ligament the lower half of the

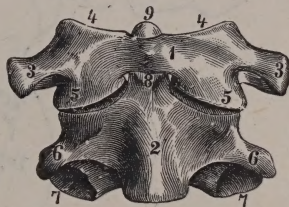


Fig. 178.—Atlas and axis; ventral surface.

back of the process. The canal for the vertebral artery is so curved that the plane of the outer border of the lower opening, if prolonged upwards, lies internal to the inner border of the upper opening. The laminae are stronger than those of any other cervical vertebra.

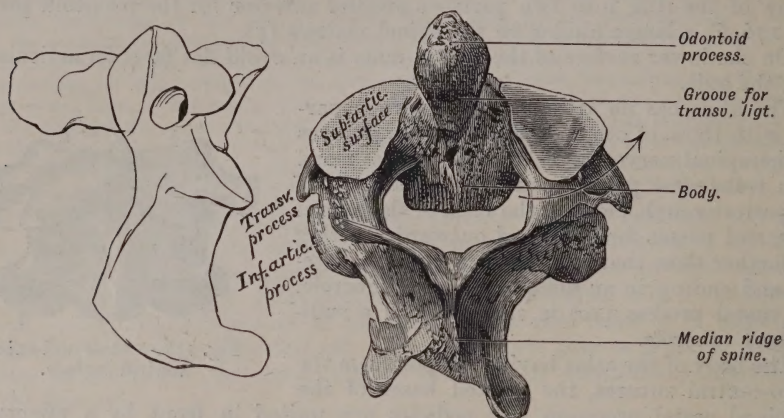


Fig. 179.—Axis, seen from behind, and on its right side.

69. DORSAL VERTEBRÆ.—Each dorsal vertebra (fig. 170) bears on the upper and outer part of each side of its body a cartilage-clad facet (5) with which a movable rib articulates. The typical dorsal vertebra has a long decurrent triquetrous spinous process (fig. 171, 3), whose median and lateral ridges converge to one terminal tubercle. The transverse processes (2) are strong, directed outwards and backwards, having in front an articular concavity for the tubercle of the rib, and behind a rough tuberosity for muscular attachment. The spinal foramen (fig. 180) is circular, smaller than in the cervical or lumbar vertebrae, and the articular processes are nearly vertical and

flat, the upper (4) directed backwards and a little outwards, the lower (8) forwards and a little inwards. The bodies are somewhat triangular with flat upper and lower surfaces, curved sides and rounded angles, nearly as long sagittally as transversely, and higher behind than in front, increasing in size from above downwards. The upper nine bear small accessory costal facets on the lower margins of the bodies, below the primary costal facets

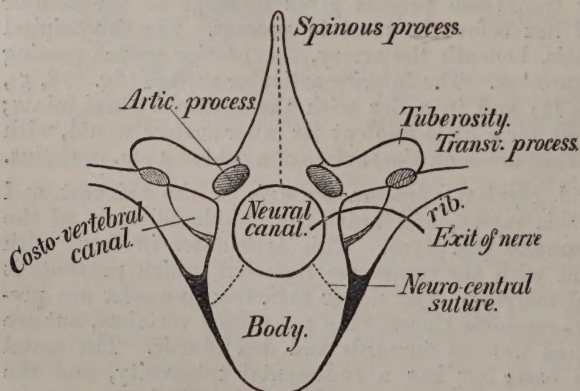


Fig. 180.—Scheme of a dorsal vertebra.

(fig. 171, 7). The pedicles have deep neural notches below (9), but scarcely any trace of a superior notch.

The increase in size of the body is due to its growth forwards, the pedicles becoming posterior, not lateral, hence the neuro-central lips of the pedicles, instead of being lateral and sagittal as in the cervical, become posterior and

nearly transverse. The venous foramen is generally single, and the anterior surface of the body is concave from above downwards, with rough prominent rims.

The relation of the vertebræ and ribs may be represented by the following scheme:—

Ribs.	Vertebræ.	Ribs.
1	I	1
2	II	2
3	III	3
4	IV	4
5	V	5
6	VI	6
7	VII	7
8	VIII	8
9	IX	9
10	X	10
11	XI	11
12	XII	12

The spines increase in obliquity to the seventh, and from thence diminish to the eleventh, or **anti-clinal vertebra**, whose wedge-shaped spine is horizontally directed backwards (fig. 181). The tip of the spine of the sixth is on the level of the upper surface of the body of the eighth.

The peculiar dorsals are the first, second, ninth, tenth, eleventh, and twelfth. The first is a passage vertebra, resembling the cervical in its transversely elongated body and foramen, oblique upper articular processes, prominent neuro-central lips, inferior tubercles on the body. It has a complete costal facet above, and a large tuberosity, from which a horizontal ridge runs beneath the upper articular process to the top of the lamina. The second dorsal has also a transversely elongated body, and distinct neuro-central lip, and the plane of the upper surface of its body bisects its pedicles which are on a higher level. From the third to the eighth the vertebræ are conformable to type. The ninth has a costal facet above on its pedicle, but no accessory facet below on its body, and the costo-transverse facet is on the upper surface of the transverse process. The tenth (fig. 181) has a single costal facet at its upper border, and a small facet on the upper surface of the transverse process. The eleventh has a single facet on its pedicle, nearer its upper than its lower surface, and none on the transverse process (fig. 181). The twelfth has its costal facet near the bottom of its pedicle, its transverse process is trifid, the tuberosity (*mammillary process*) being large and the anterior surface elongated into a basi-costal process, while the real transverse process points downwards.

The lower articular process is transversely convex and directed forwards and outwards like that of a lumbar vertebra. The bodies of the three lowest

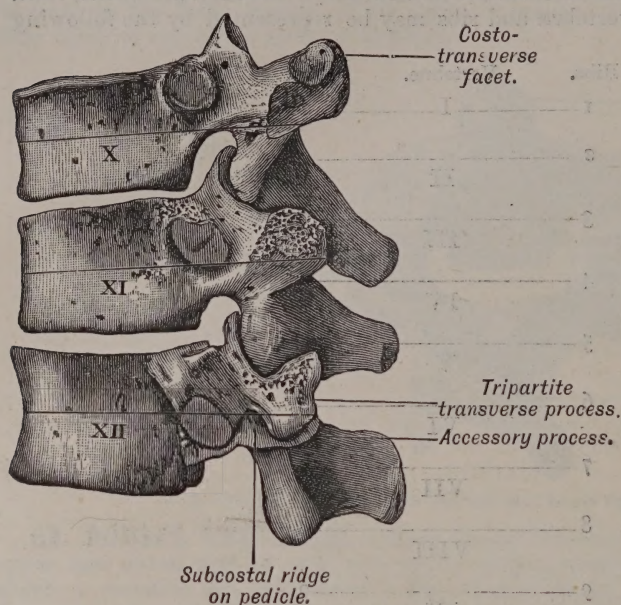


Fig. 181.—The tenth, eleventh, and twelfth dorsal vertebrae—left side view.

sisting chiefly of an exaggerated middle ridge, but with rough lateral tubercles below. The upper articular processes (4) look backwards and inwards, and

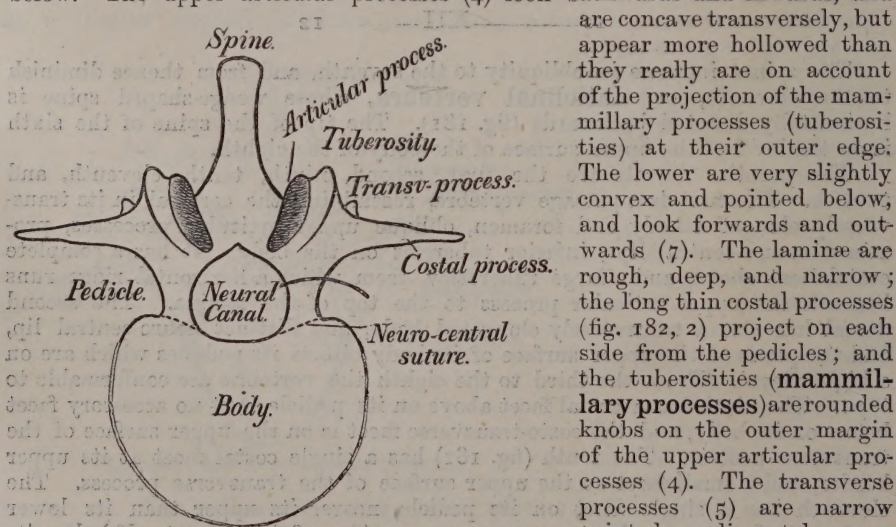


Fig. 182.—Scheme of a lumbar vertebra: preaxial surface.

below and external to these, between the costal process and the tuberosity.

Each of the five lumbar vertebrae exhibits gradational peculiarities. The first has the

dorsals have become transversely elongated, and the costal facets are distinctly behind the neuro-central suture.

The body of the fourth, seen from the front, appears the smallest, but is really not so, the appearance being due to its peculiar wedge shape.

70. THE LUMBAR VERTEBRÆ are the largest, and have a triangular spinal canal, and transversely elongated bodies (fig. 183, 1), whose upper and lower surfaces are flat (fig. 172), the spinous processes (3) are quadrate and rough-edged behind and below, projecting horizontally backwards, con-

sist of an exaggerated middle ridge, but with rough lateral tubercles below. The upper articular processes (4) look backwards and inwards, and are concave transversely, but appear more hollowed than they really are on account of the projection of the mammillary processes (tuberosities) at their outer edge. The lower are very slightly convex and pointed below, and look forwards and outwards (7). The laminae are rough, deep, and narrow; the long thin costal processes (fig. 182, 2) project on each side from the pedicles; and the tuberosities (mammillary processes) are rounded knobs on the outer margin of the upper articular processes (4). The transverse processes (5) are narrow pointed rudimental spurs (accessory processes)

most distinct transverse processes and tuberosity, the smallest costal process, and the narrowest pedicle (fig. 169). The fifth is a passage vertebra, with a wedge-shaped body, a thick, rough costal process, widely divaricated inferior articular processes (nearly as far apart as the superior), and a smaller round-edged spine. The second, third, and fourth can be distinguished by the gradually widening pedicles, the diminishing mammillary processes, and the increase in body-width and divarication of the lower articular surfaces.

In each lumbar vertebra there is a rough ridge from the tuberosity to the back of the inferior articular process, where it enlarges into a second roughness. At the base of each pedicle is a large vascular hole for a branch of the lumbar artery, to nourish the arch; those for nutrition of the body enter at each side.

The costal process consists of two parts, a basal and a terminal, which differ in thickness, and are often separated by a superficial groove.

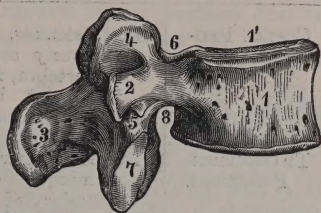


Fig. 183 a.—Second lumbar vertebra, right side view.

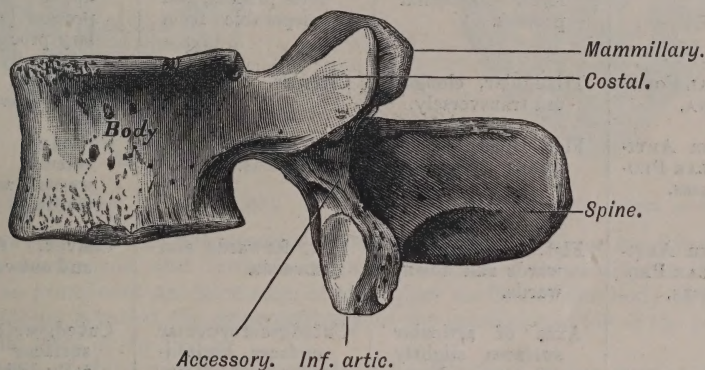


Fig. 183 b.—Fourth lumbar vertebra, left side.

The following table exhibits the characters of each part of the vertebræ of each series :—

	Cervical.	Dorsal.	Lumbar.
BODIES.	Broadest transversely. Surfaces concave. No costal facets.	Nearly equal transversely and sagittally. Surfaces flat. Costal facets.	Broadest transversely. Surfaces flat. No costal facets.
PEDICLES.	With neuro-central lips lateral, and sagittally placed, notched below and above.	Neuro-central lips rudimental, posterior transversely placed, notched below.	No neuro-central lips. Deeply notched below.
LAMINÆ.	Long, thin, flattened.	Short, vertically elongated.	Short, rough, vertically elongated.
SPINES.	Bifid, depressed, with weak median ridge and diverging lateral tubercles.	Long, decurrent, imbricating with single terminal tubercle and strong median ridge.	Quadrato, directed backwards, horizontally, reduced to a median ridge.

	Cervical.	Dorsal.	Lumbar.
COSTAL PROCESSES.	Flat, slender, continuously ossified to vertebra, forming front boundary of foramen.	A detached bone (rib).	Continuously ossified to vertebra, flat and thin.
TRANSVERSE PROCESSES.	Directed forwards, forming outer boundary of foramen—joined to costal process by bony lamella.	Directed backwards, articulating with rib by ligaments.	A rudimental spur (accessory process).
TUBEROSITIES.	Sessile on back of inferior articular process.	On back of transverse process, and inseparable from it.	A knob outside the upper articular process (mammillary process).
SPINAL FORAMINA.	Triangular, elongated transversely.	Circular.	Triangular, elongated transversely.
UPPER ARTICULAR PROCESSES.	Flat, directed backwards and upwards.	Flat, backwards and outwards.	Concave transversely, backwards and inwards.
LOWER ARTICULAR PROCESSES.	Flat, directed forwards and downwards. Axes of articular surfaces slightly converge downwards and forwards.	Flat, forwards and inwards. Cut edges of articular surfaces horizontally divided coincide with arcs of a circle whose centre is situated at anterior lip of body in middle line.	Convex, forwards and outwards. Cut edges of articular surfaces horizontally divided coincide with arcs of a circle whose centre is at root of spinous process.

71. SACRUM.—The five sacral vertebrae are united in the adult into a curved triangular bone of spongy texture, upon the sides of which the pelvic girdle abuts, and which forms the hinder wall of the pelvic cavity. In the upright body the sacrum lies obliquely, with its upper surface directed forwards and upwards, so that a horizontal plane continued backwards from the anterior margin will cut the spine of the second sacral vertebra.

The sacrum presents an anterior and a posterior surface, two lateral margins, a base and an apex. The anterior surface (fig. 184) is smooth and concave, slightly from side to side, strongly from above downwards, and is directed downwards and forwards. It presents medially the flat faces of the bodies of the component vertebrae separated by four transverse ridges, the ossified intervertebral discs (fig. 184, 4). These bodies diminish slightly in width from above downwards; the upper two are of equal height (30 mm.): the lower three are not so high, but are nearly equal to each other (20 mm.).

At the outer extremity of each intervertebral line on each side is a round hole (5) for the exit of the anterior branches of the sacral nerves. These **anterior sacral foramina** form a vertical row on each side, separated from each other by the wide costal processes which unite externally to the foramina,

into a continuous **lateral mass** (3) grooved anteriorly for each sacral nerve, and rough around the second, third, and fourth for the origin of the *pyriformis* muscle.

The base presents medially an elliptical intervertebral surface for the lumbo-sacral disc (1), behind which is the triangular spinal canal (fig. 185, 10),

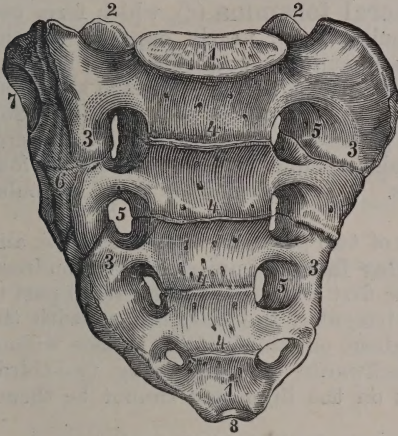


Fig. 184.—Sacrum, ventral surface.

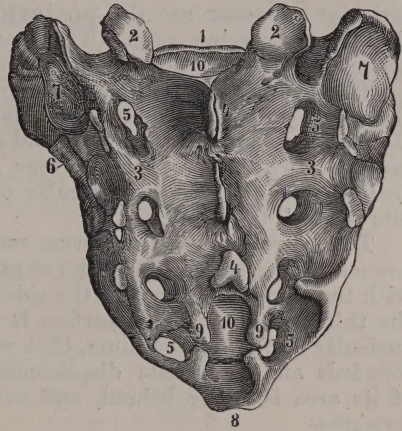


Fig. 185.—Sacrum, dorsal surface.

having on each side the flat superior articular process (2) whose facet is directed upwards, backwards, and inwards, with a rudimental tuberosity at its outer side. The prominent anterior edge of the upper surface of the body of the first sacral vertebra is called the **promontory** of the sacrum, and forms the posterior part of the brim of the pelvis.

In front of the articular process the intervertebral groove crosses the neck of the pedicle (fig. 186, Fi) and divides into two parts, one going forwards to the side of the body (Fsa), the other backwards between the articular process and the lateral mass (Fsp).

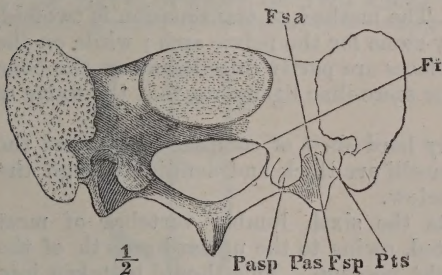


Fig. 186.—Upper surface of second sacral vertebra, the first removed.

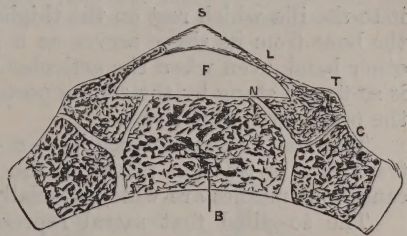


Fig. 187.—Horizontal section of first sacral, showing the costal portion, C, abutting on the body, B. N, neurocentral suture; S, spine; L, lamina; T, transverse process.

The large *lateral mass* as seen from the base is called the **ala**, and presents a rough surface above, convex sagittally, flat or concave transversely, whose longest margin is its outer.

The apex of the sacrum (8) is the ellipsoidal lower surface of the fifth sacral vertebra, which is joined to the first coccygeal by an intervertebral disk.

The posterior surface (fig. 185) is rough and convex, having in the middle line the spines of the three or four upper sacral vertebrae (4) often united into a

vertical ridge by ossified ligaments. On each side are the laminae, united by ossified interlaminar ligaments. Those of the fifth vertebra are always, those of the fourth usually, incomplete behind (9), the gap in the hinder wall of the spinal canal (**hiatus sacralis**) being closed by ligaments. The articular masses are ankylosed into a series of rough knobs; those of the fifth sacral vertebra project downwards, and form the **cornua sacralia**. Outside these articular processes are the **posterior sacral foramina** (5), which form two slightly converging rows. These are smaller than, nearly opposite to, and communicate with, the anterior foramina, and emit the posterior sacral nerves.

The intervertebral canals in the sacrum pass singly out on each side from the spinal canal, and bifurcating, end at these two sets of foramina (fig. 186). Outside these are the transverse and costal processes consolidated into the lateral mass (7), which here exhibits four irregular oblique ridges separated by four shallow irregular pits for muscular origins. The uppermost of these muscular pits is much the deepest.

The lateral edge of the sacrum consists of two parts, an articular above, and a non-articular below, the former or **auricular facet** (6) unites by synchondrosis with the ilium, and occupies the side of the first and second and a small part of the third vertebra. This surface is very irregular, and dovetails so with the auricular surface of the ilium, that while about one-third of its surface widens forwards and so resists displacement backwards, the remaining two-thirds of its area is wider behind, and so rests on the ilium and cannot be thrust forwards.

The lateral margin below the auricular facet is divisible into two parts:—1st, The **lateral tuberosity**, the rough border of the lateral mass of the third and fourth sacral vertebrae, to which the sacro-sciatic ligaments are attached; 2nd, the sharp upper edge of the lateral process of the fifth sacral, which forms, with the tuberosity, an **inferior lateral angle**, and passes inwards to the side of the body of the last vertebra. Around this border passes the fifth sacral nerve.

The sacrum, as a whole, articulates with four bones, the two hip bones, the coccyx, and the last lumbar vertebra, and gives origin to five pairs of muscles and twenty ligaments.

The sacrum bears the weight of the upper part of the body, and transmits it to the ilia which rest on the thighs. The method of transmission is twofold, the bone from its shape serves as a key-stone for the pelvic arch; while on the other hand, even when the articular surfaces are partly chiselled away, the bone is so firmly slung by the strong posterior sacro-iliac ligaments, that the fixity of the pelvic arch is preserved.

The alae in consequence have a very hard shell of compact tissue, and the transverse or traction planes of the cancelli are thick and definite, though the cancellous meshes are wide, especially below.

The so-called first sacral represents the sixth lumbar vertebra of most quadrupeds, which has become assimilated, owing to the upward growth of the pelvic bones correlated with the upright position. This should be taken into account in comparing the numerical relations of the human vertebrae with those of mammals. The fourth and fifth sacral vertebrae represent the first and second caudal vertebrae of mammals, the two real sacral vertebrae being the second and third. The varying conditions of the lumbo-sacral passage-region, especially in the lower races of man, depend on these changes. Fig. 187 shows that in the first sacral vertebra the costal process abuts on the body, but on the third it is separated by the base of the arch. The costal process of the third sacral vertebra is usually thin and sharp-edged on the ventral surface.

The normal adult male sacrum is about 105 mm. high and about 117 broad,

the female about 101 high and 118 broad; these relations are represented by the sacral index $\frac{\text{breadth} \times 100}{\text{height}}$. Sacra, such as those of Europeans, in which this index exceeds 100, are called *platyhieric*, those under 100 are *dolichohieric*, as in most of the black races. The sacral index of British males is about 112.4, of females 116. The varieties of width depend on the width of the lateral mass, not on that of the body. As a rule, all females are *platyhieric*.

72. COCCYX.—The caudal vertebræ are represented by rudimental bodies without arches, which in the adult ultimately fuse into a single bone. The first is transversely elongated, with an elliptical upper facet (fig. 188, 1) united by fibro-cartilage to the fifth sacral vertebra, having a stumpy costal process jutting out at each side (3), and a cornu or pedicle projecting upwards and tied by fibrous tissue to the cornu of the sacrum. In the second, these are represented by two little knobs, the third is an irregular bony nodule, and the



Fig. 188.—Coccyx, ventral surface.



Fig. 189.—Coccyx, dorsal view.

fourth is still more irregular, being an ossification, not in one vertebral body, but in a fibro-cartilaginous knob, formed by the union of the rudimental bodies of the four hindmost vertebræ of the human tail. The coccyx, as a whole, is triangular, concave in front, continuing the curve of the sacrum, crossed by three lines of intervertebral ankylosis; the posterior surface (fig. 189) is convex and the edges rough, presenting three notches. The apex (2) is generally nodose, the fourth element exceeding the third in bulk.

The coccyx articulates only with the sacrum, and gives attachment to three pairs of muscles and three pairs of ligaments.

73. DEVELOPMENT OF THE AXIAL SKELETON OF THE TRUNK.—The first skeletal structure which appears in the embryo is the notochord and the mesoblastic sheath



Fig. 190.—Scheme of vertebral bodies forming around the notochord—*li.*, fibrous sheath.

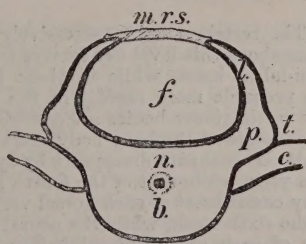


Fig. 191.—Scheme of early development of a dorsal vertebra—*n.*, notochord; *p.*, pedicle; *t.*, transverse process; *c.*, rib.

around it which cleaves into protovertebræ. When these have undergone the secondary division already described (§§9, 11), the tissue which makes up the resulting secondary

vertebræ becomes cartilaginous and forms a segmented axis (fig. 190, *n*), consisting of a series of thirty-six short cartilaginous bodies (*b*), extending as a column from the head downwards, through which the notochord (*n*) extends to the very end; two small mesoblastic rudiments of vertebræ appear behind these at the extremity of the notochord, but never chondrify. There are thus traces of thirty-eight vertebræ in the primitive column.

From the sheath of the notochord a continuous *post-neural lamella* projects backwards on each side to unite with its fellow in the median line, forming an unsegmented sheath for the entire length of the neural canal (*membrana reuniens superior*—fig. 191, *m.r.s.*). In this membrane two small rods of cartilage form and (fig. 191, *l*) project backwards, one on each side from each cartilaginous vertebral body, and ultimately meet in the medio-dorsal line. These confluent rods make the cartilaginous neural arches of the vertebræ, and at the end of the fourth week the vertebral column consists of a row of twenty-eight gristly vertebræ, each consisting of a body and a neural arch. The first arches to chondrify are those of the third vertebra, the last are those of the twenty-eighth; the twenty-ninth to the thirty-second consist only of bodies and never develop arches; the thirty-third to the thirty-sixth atrophy and fuse into a terminal piece, while the two hindmost never chondrify at all.

From the ventrolateral side of the sheath of the notochord a thin mesoblastic lamella extends outwards, to be lost in the base of the somatopleura. On the level of the preaxial surface of each vertebral body, a slender cartilaginous strip, at first continuous with the vertebra, appears in this membrane about the fifth week, directed outwards towards the ventral wall, and varying much in length in the different regions of the body; these are the costal processes (fig. 191, *c*).

Ossification.—The first trace of ossification in the axial skeleton appears about the thirty-eighth day on each side of the *neural arch* of the first vertebra, and during the following week the arches of the vertebræ below begin to ossify in successive order.

These lateral ossifications come in contact medio-dorsally, and begin to unite in the dorsal region in the seventh month after birth. Ossification begins in the *body* of the nineteenth vertebra about the forty-ninth day, by two closely approximated centres which speedily

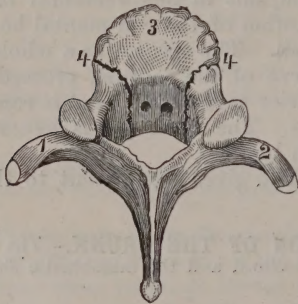


Fig. 192.—Young dorsal vertebra.

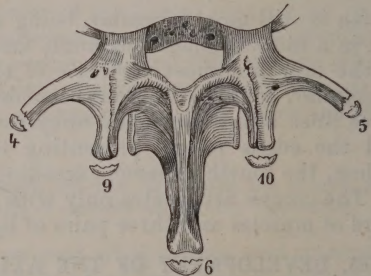


Fig. 193.—Scheme of ossification of lumbar vertebra, showing the centres for the extremities of the costal, mammillary and spinous processes.

coalesce. The vertebræ ossify successively upwards and downwards from this region, but in the vertebræ above this level the centres are usually single, the lateral nuclei having coalesced into one bi-lobed mass, while in those below they are double. In the upper vertebræ ossification proceeds more rapidly in the arches than in the bodies, and consequently the sides of the cartilaginous bodies are ossified on each side from the bases of the arches, so that the line of junction of the bony body and arch (*neuro-central suture*) encroaches on the body (fig. 192, 4). This suture disappears by synostosis, that in the third vertebra ossifying first in the third year, while that of the fourth lumbar becomes closed last, about the sixth year. The primary costal facet of each dorsal vertebra is behind the neuro-central suture.

About the sixth week, while the neural arch is yet cartilaginous, a thickening appears in the middle of each of its lateral halves. These enlargements (*articular masses*) extend upwards and downwards so as to come in contact with the corresponding parts of the arches of contiguous vertebræ, and their surfaces form the articular processes. It is in this region that the ossification of the arch begins. The lateral half-arches of cartilage unite medio-dorsally about the fourteenth week, and from the hinder surface of the arch so formed the spinous process projects backwards, preformed in cartilage. The whole of each side of the neural arch, including the articular mass, is ossified from a single centre, but in the swollen end of each spinous process a secondary centre usually arises (fig. 193). In a few vertebræ,

especially the twentieth, twenty-first, and twenty-second, a second ossifying centre appears at the base of the spine.

In the early stages of their development, as the cartilaginous bodies increase in size, the included portion of the notochord atrophies (fig. 190, *n*), and by the sixteenth week has become lost in the tissue of the vertebra. A part of the embryonic chord-sheath (*li*) remains unchondrified between each of the vertebral bodies, and becomes modified into the pulpy nucleus of the intervertebral substance. Part of the post-neural lamella also survives between the successive neural arches, forming the primitive ligaments of this region.

The transverse processes are outgrowths of the cartilage on each side of each neural arch, behind the rib and articular processes. They subsequently ossify from independent centres, and vary in size in the different regions. On the surfaces of the mammillary processes of the lumbar vertebra independent osseous crusts form.

The latest secondary centres of ossification to appear for each vertebra are two thin irregular marginal rims, very imperfect and irregular rudiments of the epiphysary plates of other mammals, one on the upper and one on the lower surface of each vertebral body. They appear first in the lumbar region in the seventeenth year, consolidating in the twenty-fifth year.

The proportional length of the vertebral column to the stature varies at different ages.

At 3 weeks (foetal)	the spine is to the stature as	3 : 4
" 5 "	" "	3 : 5
" 6 "	" "	3 : 6
" 15 "	" "	3 : 7
" 18 "	" "	3 : 7.3
" 25 "	" "	3 : 7.1
" 7½ months "	" "	3 : 7
" 9 "	" "	3 : 6.8
In the adult	" "	3 : 7.5

The atlas ossifies from three primary nuclei; one appears on each side of the posterior arch at the back of the lateral mass about the forty-ninth day; from these the hinder arch and the greater part of the articular portion develop. Ossification begins in the anterior arch by a single nucleus in the first year (fig. 194, 3). The lateral nuclei unite posteriorly in the third year, and the anterior arch consolidates in the sixth year.

The axis presents the usual body-centre (fig. 195, B) appearing in the twentieth week, the arch centres appearing about the eighth week, and the centres for the spinous and transverse processes about the seventh year. Besides these there are two lateral centres for the odontoid process, beginning at the twenty-fifth week, and uniting into a bi-lobed mass in the thirty-third week (OD). An apical centre, the upper epiphysal lamella of the atlas (AP), arises early in the second year and consolidates in the fourth. The odontoid becomes ossified to the body of the axis during the third year.

The intervertebral space (IV.) between these united bodies never completely obliterates, and a small cartilaginous trace always remains, containing the first **nucleus pulposus**. Rudiments of the upper epiphysal lamella of the axis and the lower lamella of the atlas may appear in this space about the twelfth or thirteenth year (EP. 1 and EP. 2).

Each sacral vertebra has three primary centres, one for the body, double in the first and second, single in the others, and one for each side of the arch. The former appear, the first in the eighth week, the second in the ninth, the third in the tenth, the fourth in the fourth month, and fifth in the fifth. The first laminae begin to ossify in the fifth month, the second in the sixth, the third and fourth in the eighth. The laminae of the third and fourth join the bodies in the third and fourth years respectively, those of the second in the fourth, those of the first in the sixth year. In the four upper sacral vertebrae the costal portions of the lateral masses ossify from distinct centres, appearing at the outer border of the foramina in the seventh and ninth months (fig. 196, 2); these solidify with the bodies in the fourteenth year. About the fifteenth year epiphysal plates appear for all the vertebrae (7), and in the eighteenth year separate epiphysal laminae form on each side for the auricular facet (8) and for the tuberosity (9). Consolidation of the sacral vertebrae begins at fifteen by the fusion of the costal processes, followed by union of the arches and bodies. The bones unite from below upwards, and the union is completed by twenty-six. There are altogether thirty-seven centres for the sacrum, five for the bodies, and ten for the epiphysal lamellae, five pairs for the arches, four pairs for the costal processes, and two pairs of marginal epiphyses.

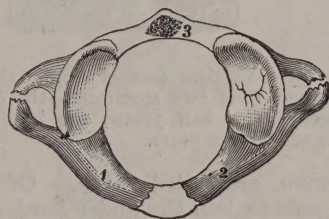


Fig. 194.—Atlas of child eighteen months old.

The coccyx ossifies from four centres, the first appearing about four months after birth, the second in the fifth year, the third in the ninth year, the fourth about the sixteenth year. Ossification in these bones is a full year later in females than in males. The second and third ankylose together about twenty-five, the fourth unites about thirty, the first about forty. Ankylosis with the sacrum takes place later.

The rates of growth of the different regions of the vertebral column vary at different ages and present many individual variations. The following table of percentages illustrates this:—

	Cervical.	Dorsal.	Lumbo-sacral.
In a foetus of 85 mm. (12 weeks),	24.5	47	28.5
" " 130 mm. (15 "),	24	50	26
" " 160 mm. (18 "),	26.5	57.5	26.0
In a newborn infant,	18	45	37
In a girl of seven years,	16	42	42
In an adult male,	16.5	41.5	42
In an adult female,	16	40.5	43.5

74. RIBS.—The twelve pairs of dorsal costal processes remain as separate

arched bones, extending from the vertebral column into the body wall and bounding the cavity of the thorax (fig. 197). Each rib originates as a strip of cartilage, which for the most part ossifies ectosteally, but its ventral extremity remains permanently as gristle, so each rib consists of a bony and a cartilaginous segment.

The seven uppermost pairs of ribs unite medio-ventrally with the sternum, and are called **true ribs**; the five lower, which do not join the sternum, are called **false**. Of these the cartilages of the upper three turn upwards to join the under borders of their respective predecessors. The two lowermost are called **floating ribs** (11 and 12), as their ventral ends are free in the muscle of the body wall.

The **head** (fig. 198, Cpt) of each rib shows a cartilage-covered facet on its extremity. In all but the 1st, 10th, 11th, and 12th, this is divided into two by a transverse ridge (**crista capituli**—CCpt), the lower or primary facet being the larger, to articulate with the vertebra which corresponds to the rib in number; the upper or secondary facet being smaller, to articulate with the vertebra above. The single facets on the 11 and 12 are in series with the lower facets on the others.

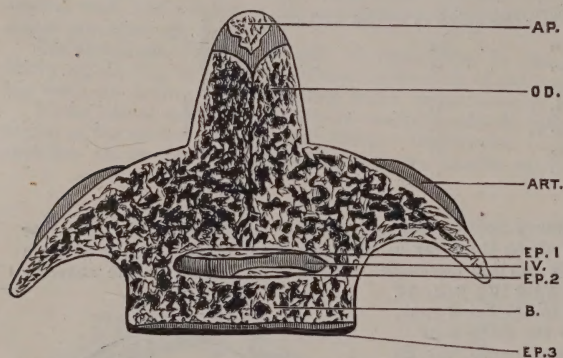


Fig. 195.—Vertical coronal section through axis, agammatised from two specimens—the odontoid from one of three and a half years; the intervertebral space from one of fourteen years.

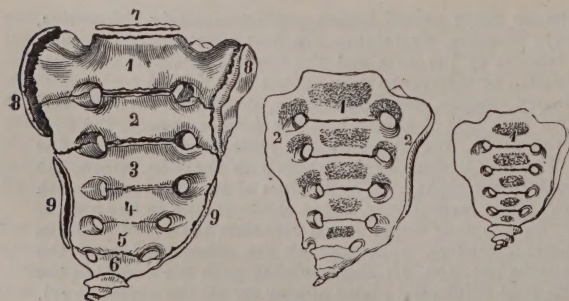


Fig. 196.—Ossification of the sacrum—at five months, at birth, and at twenty-two years.

Joining the head and body is a flattened **neck**, which presents a sharp ridge directed upwards (**crista colli superior**—fig. 198, C Cs), a smooth front, and a very rough back.

Where the neck joins the body a **tubercle** (fig. 200) projects backwards and downwards, bearing an articular surface, which rests on the transverse process of the vertebra corresponding to the rib in number. The two floating ribs have no tubercles, that of the 10th is rudimentary, with no articular surface, that of the 9th has a very small, irregular surface, that of the first is directed backwards.

The **body** is a thin, curved band of bone, with a concave, smooth surface directed inwards, and a convex, rougher outer surface, a roundish edge directed upwards, and a grooved border, with a sharp external edge directed downwards (fig. 198, Sci); the groove accommodating the intercostal vessels and nerve. A short distance from the neck its shaft is suddenly bent forwards, making the **angle**, the hinder surface of which is rough for the attachment of the *ilio-costalis* tendon. The anterior end of the body is broader, thinner, porous, and hollowed to receive the end of the costal cartilage.

The ribs are curved around two axes. Besides the main curve around the vertical axis, there is a secondary curve around a transverse axis; this increases from above downwards, causing an increased obliquity in the ribs.

No rib lies in a horizontal plane, and hence truly horizontal sections through the thorax cut the ribs obliquely. A section through the middle of the 1st dorsal vertebra cuts the neck of the 1st rib at each side; through the upper part of the 11th cuts the angle of the 1st and the neck of the 2nd; through the 11th cuts the cartilage of the 1st, the body of the 2nd, the neck and tubercle of the 3rd; through the 14th (fig. 185) the top of the head of the 5th and successive parts of the 4th, 3rd, and 2nd; through the 17th, the 6th, 5th, 4th, 3rd; through the 18th, the 7th, 6th, 5th, 4th; through the 19th, the 8th, 7th, 6th, 5th, and 4th; through the 20th, the 9th, 8th, 7th, 6th, 5th, and 4th; through the 21st, the 9th, 8th, 7th, 6th, and 5th; through the 22nd, the 10th, 9th, 8th, 7th, 6th; through the 23rd, the 11th, 10th, 9th, 8th; and finally through the 24th, the 12th, 11th, 10th, and 9th. These levels vary, however, with the condition of the thorax; the ribs are more oblique in the female and in the round-shouldered, less oblique in the young and in the attitude of "attention."

When any rib except the first and second is laid with its lower edge on the table, its vertebral end rises, and its lower edge only touches the table at two places.

Most of the ribs from the fourth to the tenth have a **crista colli inferior** (C Ci) as well as one above. On the fourth to the ninth, for a short distance

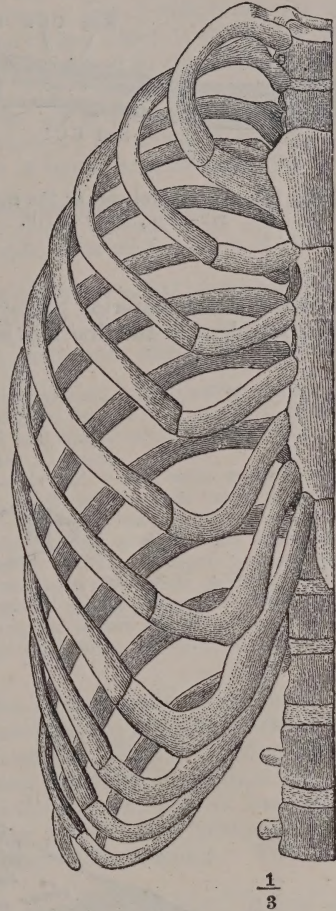


Fig. 197.—Ventral aspect of right half of thoracic wall, showing the cartilages of the ribs.

above the tubercle there is a shallow **sulcus costalis superior** (Ses) looking backwards, formed by the upward prolongation of the upper margin, to which

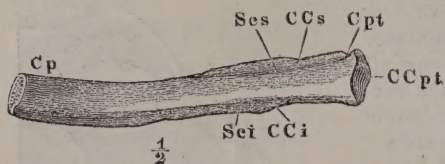


Fig. 198.—Vertebral end of the right sixth rib—Cp., body of rib,



Fig. 199.—Horizontal section through the upper part of the fifth dorsal vertebra, cutting successively the fifth, fourth, third, and second ribs, and touching the lowest limit of the sternal attachment of the cartilage of the first.

is attached the anterior transverso-costal ligament. The angle and tubercle are coincident in the first rib, but the distance between these points increases

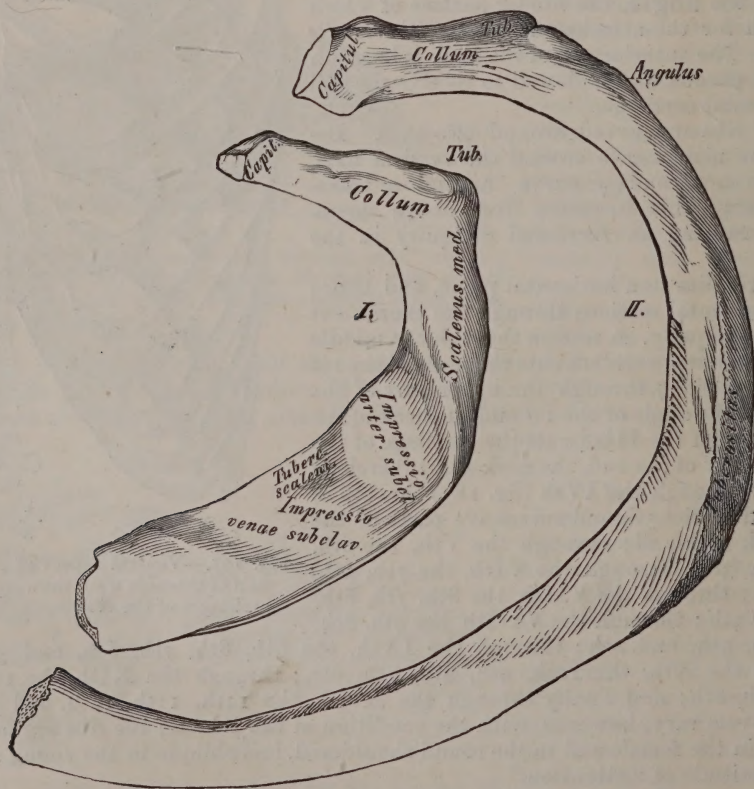


Fig. 200.—First and second ribs of the left side.

from above downwards. The ribs increase in length from the first to the eighth, then rapidly diminish to the twelfth.

The first rib is the most curved, deepest, strongest, and shortest, with the longest neck, and it lies for its whole extent nearly in one plane. Its upper and anterior surface from the angle forwards presents, 1st, a roughness for the insertion of *scalenus medius*; 2nd, a groove or impression for the subclavian artery; 3rd, a small rough surface, misnamed a tubercle (*tub. of Lisfranc*), close to its concave border, for the *scalenus anticus*; 4th, a groove for the subclavian vein; 5th, a ridge for the costo-clavicular ligament and a roughness for the *subclavius*. These last are close to or on the cartilage, which is short, flat, and irregular, often sheathed with bone, and directly attached to the sternum without the intervention of any synovial membrane. The lower surface is uniformly flat, looks downwards and backwards, and has no groove; its outer half is rough, and gives attachment to intercostal muscles; its inner is smooth and lined by pleura. In structure the concave edge is strong and compact (fig. 200).

The second rib (fig. 200) can also lie flat on the table, and has a round, but two-faceted, head, a faint intercostal groove, and a rough surface at and external to its angle for the *scalenus posticus*. A still larger tuberosity on the outside of its shaft in front of the angle gives origin to the *serratus magnus*.

The third rib is longer, a little more oblique, simple in curvature, and stronger in groove.

The tenth rib, while long and curved, with a deep groove, has but one facet on its head. The eleventh has no tubercle, but the trace of an angle and groove, and a single capitular facet. The twelfth has no tubercle, angle, nor groove, and a small, single facet, and like the eleventh, has a short, pointed cartilage in front.

Reduction in ribs seems correlated with higher development. The twelfth and eleventh ribs are diminishing elements, the twelfth being variable in length in different individuals, from 1 to 15 cm.; and the first is becoming shortened and consolidated. The twelfth rib of the male averages 103 mm. in length, that of the female, 83·8 mm.

Development.—Ribs are among the most vascular of bones, each receives several branches from the intercostal artery. These in the shaft run towards the vertebral end, while those in the tubercle and neck run forwards. The shaft ossifies from a single point, which appears at the angle at the eighth week, and rapidly extends both forwards and backwards, reaching its foremost limit about the fourth month. A small nucleus appears in the cartilage of the head of the third rib at 15; and soon afterwards in those above and below in order. These join the shafts about 24. A second epiphysis appears a little later for the tubercle; that for the sixth rib at about 16 years, the others appear later, and all consolidate at 25. There is no tubercular epiphysis for the tenth, eleventh, or twelfth ribs, and often no head epiphysis for the first.

The rib cartilages resemble in shape the sternal ends of the bony ribs, although they are less flattened. Each is enveloped in a thick perichondrium, and in advanced age they partly ossify by endostosis. That of the first is short, thick, and irregular, and like that of the second and third is continued forward in the line of the rib. That of the seventh is the largest; that of the eighth is upturned to join that of the seventh, becoming pointed and flattened in front below it. It is occasionally, but rarely, prolonged to the sternum. Those of the fourth to the ninth ascend forwards.

The coefficient of elasticity of the costal cartilages is 875. A rod of rib 1 square centimetre in section breaks under traction with the weight of 17,000 grammes. It can bear the compression of a weight of 15,700 grammes, and the torsion strain of a weight of 23,900.

The cartilages of the true ribs are usually unsymmetrical.

75. THE STERNUM is a light flat bone in the front wall of the thorax, whose loose cancellous structure is invested with a thin compact shell, and contains red marrow. The surface is porous, slightly convex in front and concave behind. Its upper end, palpable through the skin, is on the level of the lower border of the second, its lower end on the level of the ninth dorsal vertebra. It consists of three parts, **presternum** (manubrium, fig. 201, 1), **mesosternum** (body, 2), and **metasternum** (ensiform cartilage, 3). The first is the uppermost, broadest, and thickest part, bearing on each side three

articular surfaces, an upper, large and saddle-shaped for the clavicle (5), a middle, irregular for the cartilage of the first rib (6), and a lower or half facet, for the upper border of the second rib cartilage (7). Between the two clavicular facets the upper border is depressed into a **presternal notch** (4) in the middle line.

Each lateral border of the mesosternum shows four complete and two half facets for rib cartilages, the topmost of these is the half facet for the lower border of the second, the lowest for half of the seventh (12), the four intermediate (8, 9, 10, 11) for the third to the sixth rib cartilages: that for the third rib is nearly on the level of the mid point of the bone. The intercostal notches on the margin are narrow and rough, and become successively shorter from above downwards. The mesosternum is widest between the fifth rib cartilages, but

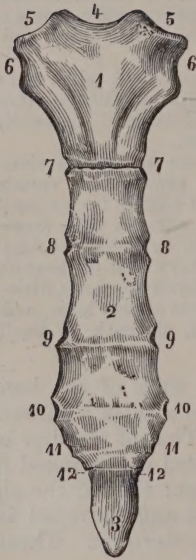


Fig. 201.—Sternum.

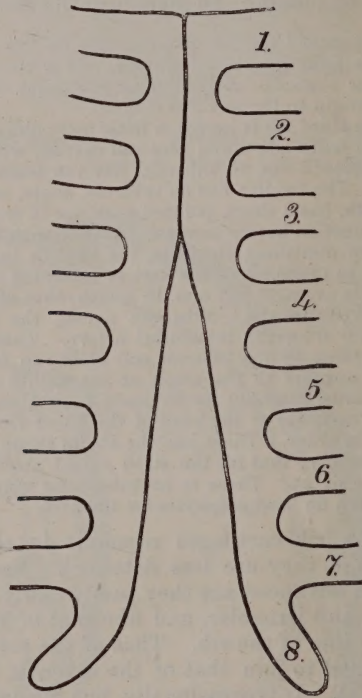


Fig. 202.—Diagram of the primitive formation of the sternum.

narrows above and below that point. The metasternum is irregular, usually notched or bifid below, placed on a plane behind the cartilage of the seventh rib, whose lower border makes an imperfect half facet on its upper and lateral edge.

The sternum lies obliquely in the body, its lower end being in front of its upper. The presternum is thickest at the clavicular facets which look upwards, backwards, and outwards, and are sagittally convex but transversely concave. The synchondrosis of the first rib lies directly below this, the sternum being excavated to receive the cartilage. The front surface is marked with a faint T-like ridge (1), the cross ridge on each side giving origin above to the *sternomastoid*, while below and on each side are two shallow **pectoral depressions**; below the clavicular surfaces on the hinder surface are two rough areas of origin for the *sterno-hyoid* muscles. The ribs between the second and seventh inclusive

join the sternum by plane synovial joints (§ 30); that for the second has two synovial sacs, a pre- and a meso-sternal; that for the seventh has but one, a mesosternal.

The mesosternum is more than twice the length of the presternum in the male, but less in the female. To its lateral margin posteriorly, the *triangularis sterni* is attached, and to the sides of the metasternum the *diaphragm* and tendons of insertion of the *internal oblique* and *transversalis* are attached.

When ribs first appear as cartilaginous bars in the embryo, their anterior ends turn upwards and fuse together on each side of the middle line, leaving a median fissure, bordered by two cartilaginous strips, into which the front ends of at least nine ribs are confluent on each side. These come in contact medially, and fuse from before backwards, and so make a continuous central sternal cartilage. In the progress of growth the sternal connection of the eighth rib generally disappears; that of the ninth becomes subdivided, one part remaining attached to the sternum as the metasternum, while the rib itself recedes therefrom.

Development.—Ossification begins in the presternum by a single centre about the sixth month, sometimes supplemented later by small accessory centres. The mesosternum ossifies usually from seven or eight centres, of which one is above the third rib, appearing early in the eighth month, and three pairs between the articulations of the lower true ribs. The upper two pairs begin to appear respectively in the end of the eighth and in the ninth months. The lowest pair appear in the mesosternum ten months after birth, by which time the upper pairs in each segment have medially united. The lowest pair unite about six years, at which time the mesosternum consists of four successive segments, which unite at twenty-five, but traces of the transverse ridges of union persist through life, especially on the front of the bone, the junction lines appearing on the levels of the rib cartilages. The metasternum begins to ossify near its upper border at the fifteenth year, and joins the mesosternum at forty. The pre-mesosternal joint persists until advanced age, and when it ossifies the union is generally superficial and the cartilage persists within. Thin crusts of epiphyses appear on the clavicular surfaces about twenty-five (*d' d*), and soon become united. The presternum has become specialised from its relation to the shoulder girdle, to which, however, its connection is secondary. The lower part of the sternum is a diminishing bone.

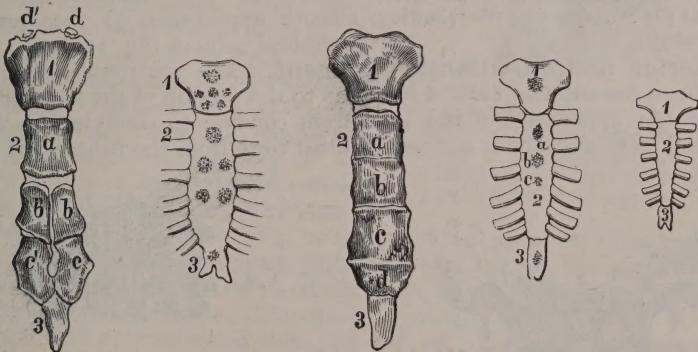


Fig. 203.—Development of sternum in the fifth month, at birth, at thirteen years, and at sixteen years. The sternum at thirteen (the figure to the left) was taken from one which showed an interval between the lateral centres, not an uncommon condition. The next figure is that of a sternum at birth, with an unusually large number of bony nuclei in the presternum.

76. INTERVERTEBRAL JOINTS.—The vertebral bodies form with each other a series of synchondroses. The whole column is enveloped in a sheath of vertical white fibres, continuous with the periosteum and pierced by the vessels passing in and out of the bodies. This sheath is weak and interrupted at each side, but is thicker medially both in front and behind, and specialises into two continuous bands, the **anterior** and **posterior common ligaments** of the spine.

The **anterior common ligament** (fig. 204, 12) appears above as a narrow median septum between the two *longi colli* muscles, with a cord-like free border

at the anterior tubercle of the atlas. Descending, it widens over the ligamentous area of the vertebræ, continuing along the front of the column to the coccyx.

On each side it is separated from the weaker lateral portion of the fibrous sheath by apertures for the entrance of vessels.

The ligament consists of two strata, the *superficial fibres* pass with a slight obliquity over three or four vertebræ; those from the atlas diverge and become attached to the lower cervicals, those from the lower cervicals converge downwards, the ligament being very narrow where it crosses the fourth dorsal, but widening again in the lumbar region. The superficial stratum is separated from the deeper opposite the middle of the back of each body by loose connective tissue and fat. The ligament receives a few reinforcing fibres from the *longus colli* opposite the second dorsal, and at the first, second, and third lumbar vertebræ it gets many additional fibres from the crura of the diaphragm. The *deep fibres* lie close to the vertebral body, to the edges of which and to the intervertebral substances, they are particularly connected. This ligament gives an even, smooth appearance to the front of the vertebral column (fig. 172).

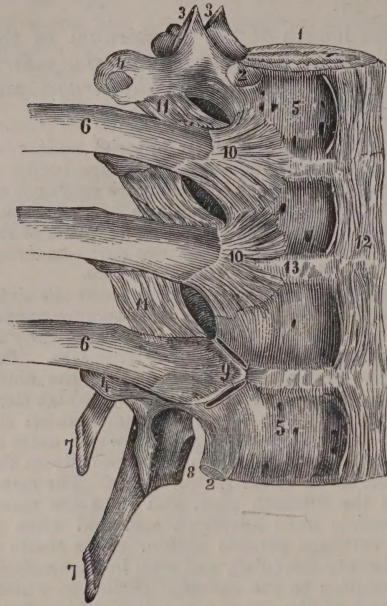


Fig. 204.—Right sides of 5-8 dorsal vertebræ and the corresponding ribs, showing ligaments.

Anterior occipito-atlantic ligament.—The continuation of this ligament above the anterior arch of the atlas to the fore-lip of the foramen magnum occupies the upper edge of the atlas from condyle to condyle (fig. 205). Its superficial part appears as a strong central cord from the tubercle of the atlas

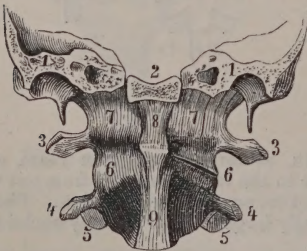


Fig. 205.—Upper portion of anterior common vertebral ligament (9) and the anterior occipito-atlantic ligament.

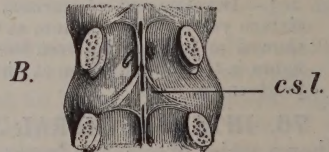
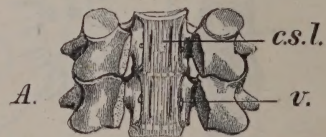


Fig. 206.—Posterior common spinous ligament—A, in the cervical region; B, in the lumbar region.

to the middle point of the occipital lip, forming a *median anterior occipito-atlantic ligament* (8), the deeper part expands on each side as a *lateral anterior occipito-atlantic ligament* (7).

Anterior sacro-coccygeal ligament.—The downward continuation of

the anterior ligament is a flat median band, the *anterior sacro-coccygeal ligament*, lost on the front of the coccyx.

The **posterior common ligament** (fig. 206, *c.s.l.*) lies on the backs of the vertebral bodies within the spinal canal, and is exhibited by sawing through the pedicles, lifting up the arches of the vertebræ, and removing the spinal cord and its membranes. It is attached above to the inner edge of the anterior lip of the foramen magnum and descends to the sacrum, attached in its course to the posterior part of the edges of the vertebral bodies and to the intervertebral substances, but is separated from the backs of the bodies by the basivertebral veins (*ib.*, *v.*). To allow of the emergence of these, it narrows opposite the middle of each body, widening at the disc, and consequently its borders appear scoloped.

The scolloping is least marked in the cervical region (fig. 206, *A*), where the ligament is widest, best marked in the lower lumbar (*ib.*, *B*) where the mid portion of the ligament is narrowed to a cord. The middle fibres of the ligament are nearly parallel, and stretch over four or five vertebræ; the lateral fibres are very oblique, extending on each vertebra to the root of the pedicle. Its superficial lamella of fibres is with difficulty separated from the dura mater in the upper cervical region. The portion between the occiput and the axis is attached to the back of the transverse ligament, and is often bilaminar, its deep layer being usually considered as a separate ligament, the **ligamentum latum axiale** (figs. 207, 8; 216, 8, 12).

Intervertebral discs.—The vertebral bodies are united into a column by the interposition of intervertebral discs (fig. 208), of which there are twenty-three between the true vertebræ, contributing about 14 cm. to the height of the body of an average man (cervical discs 3 cm., dorsal 6, lumbar 5). Each disc is as large as the face of the vertebra to which it is attached, and consists of two parts, an outer **annulus fibrosus** of concentric layers of white fibres (fig. 208, *c*), making up more than half the thickness of the disc, and a **nucleus pulposus** (fig. 172, 3), not quite in the centre, an elastic mass of angular cartilage cells in a fibrous matrix with a mucin-holding ground-substance. The nucleus contains a small cavity of very irregular shape with approximated sides (fig. 208, *a*).

A layer of hyaline cartilage, to which the disc is attached, encrusts each terminal face of each vertebra. In this the epiphysial rim develops, but the whole layer does not become fully ossified until after 50. The superficial fibres in the annulus fibrosus are vertical, continuous with the common sheath. The deeper layers are oblique, spirally disposed, those of each layer being approximately parallel to each other, and the alternate layers decussate each other nearly at right angles (fig. 208, *c*). The numbers of such layers vary within very wide limits in different discs and even in the corresponding discs of different individuals. They give to the disc when cut vertically a longitudinally streaked appearance; when divided horizontally it appears concentrically laminated. A few horizontal white fibres and a fine network of elastic fibres are distributed among these layers, making, with a little loose areolar tissue, a polygonally netted sheath for the fibres. The fibres of the outer layer are ordinary white fibres, those of the inner are peculiar in some respects, and have cartilage cells in their interspaces.

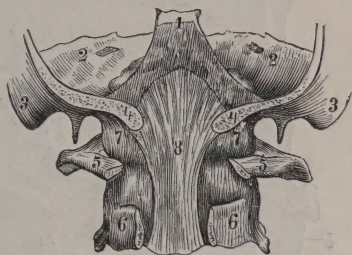


Fig. 207.—Ligamentum latum axiale —1, basilar process; 2, petrous bone; 3, mastoid process; 4, cut border of the occipital bone; 5, cut arch of atlas; 6, cut lamina of axis; 7, occipito-atlantic capsule.

The nucleus pulposus is large and elongated backwards into a narrow process in the dorsal region, it is normally compressed, so that on horizontal division of the disc it rises above the level of the cut annulus. The cavity it contains resembles a synovial sac filled by large villi. In the newborn infant it contains the liquefied remains of the notochord, which disappear completely by the fifth year, and its walls are approximated in the adult. The smallest disc is that between the fifth and sixth cervical, the second that between the second and third, the weakest spot in the cervical column. From the former

upwards and downwards they enlarge slightly in sequence. Those in the cervical region are one-third higher in front than behind; those in the dorsal are, if anything, higher behind; those in the lumbar are higher in front, the last or lumbo-sacral being wedge-shaped, 2.6 times higher in front. A rudimentary nucleus pulposus, without a central hollow, persists to senility between the odontoid process and the body of the axis.

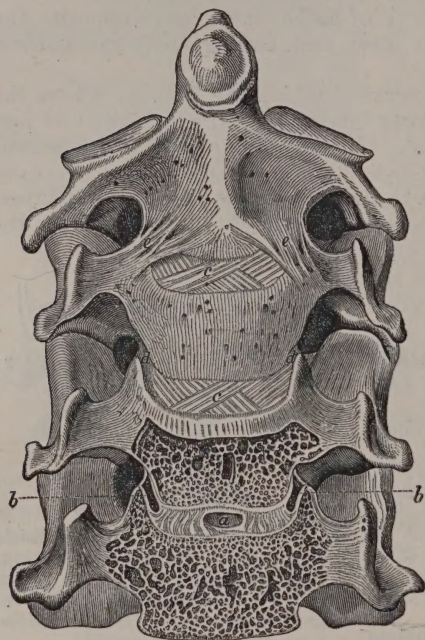


Fig. 208.—Ligaments uniting the second, third, fourth, and fifth cervical vertebrae—*b*, the cervico-costal articular cavity; *d*, layer of ligament overlying the cavity; *c*, cervical stellate ligament.

Cervico-costal joints.—In each interspace in the cervical region a small synovial cavity lies posterior and external to the intervertebral disc, between the neuro-central ridge of the pedicle and the contiguous surface of the body of the overlying vertebra (fig. 208, *b*). These cavities are in series with the synovial cavities of the costal joints below, and with the atlanto-axial and anterior occipito-atlantic joints above.

The interlaminae ligaments (*ligamenta subflava*) are thick masses of elastic fibres filling the intervals between the arches of the successive vertebrae (fig. 209). They are attached to the upper edges of the laminae of each lower vertebra, and pass vertically upwards to a rough transverse impression on the anterior surface of the laminae of the vertebra above. Each

ligament is continuous from side to side, the lateral halves uniting at an angle in the median line beneath the spine, where small vessels often traverse it, making it appear as if divided. From the dorsal surface of this angle the **interspinous ligament** is continued backwards between the spines as far as their terminal tubercles (fig. 172, 6).

These interlaminae ligaments are the purest masses of yellow fibrous tissue in the human body. In general they equal the laminae in vertical depth when seen from before, and are so disposed that the hinder wall of the spinal canal appears uniformly smooth, even in different degrees of flexure. The cervicals are the thinnest and extend outwards to the inner edge of the articular processes where they merge into the capsules. The dorsals are narrower transversely and much thicker, attached not only to the laminae but to the rough inner margin of the articular process as far as its tip. The lumbar are the strongest and longest, and extend laterally as far as the rough surface on the anterior aspect of the articular processes, and thus their thick round borders form the

hinder boundaries of the lumbar intervertebral foramina (fig. 172, 4). The upper attachment of each interlaminar ligament divides the face of each lamina into a smooth supra-ligamentous and a rough infra-ligamentous area.

Posterior atlanto-axial ligament.—The interlaminar ligament between the axis (fig. 210, 3) and the third vertebra (4) is thin, and its elastic lamella is interrupted by masses of areolar tissue (6). It becomes purely areolar and thickened at each side behind the exit of the second cervical nerve.

Posterior occipito-atlantic ligament.—The first interlaminar ligament, between the occipital bone and the atlas (fig. 210, 5), has no continuous elastic lamella, but is made up of condensed areolar tissue, closely connected to



Fig. 209. — Interlaminar ligament between the eighth and ninth dorsal vertebrae.

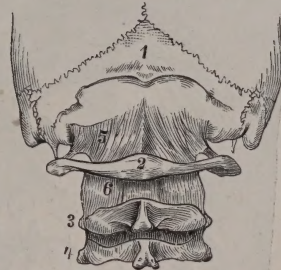


Fig. 210.—Posterior occipito-atlantic and atlanto-axial ligaments.

the dura mater in front. A strong, white band, sometimes ossified, the *oblique ligament of the atlas*, usually crosses it from the back of the sinus atlantis to the hinder edge of the upper articular surface, arching over the vertebral artery and first cervical nerve.

To expose the interlaminar ligaments divide the pedicles of the vertebrae, raise the arches from the bodies, leaving behind the spinal cord and its membranes, and cleanse the adhering shreds of connective tissue from the inside of the arches by wiping with a rough wet cloth.

The lumbar **interspinous ligaments** (fig. 172, 6) consist of two strong layers of nearly horizontal white fibres, passing backwards from the median ridge of each spine below, to the under side of the space between the tubercles of the spine above. The dorsal interspinous ligaments are weak except in the lowest three interspaces. They consist of an interrupted lamella of connective tissue with a little fat. The cervical are also weak and not easily separable from the supraspinous ligament. There is no distinct interspinous ligament between the occiput and atlas, or between the atlas and axis.

The inter- and supraspinous ligaments are specialised parts of the medio-dorsal intermuscular septum, traceable beyond the level of the spines to the fascia along the middle line of the back. The portion which lies upon the dorsal surface of the spines forms a more or less continuous band, the *supraspinous ligament* (fig. 172, 7). In the lumbar region this is inseparable from the lumbar fascia, in the dorsal it becomes reduced to a cord passing from tip to tip of the long spines (*ligamentum apicum*—fig. 212), but from the “withers” spines of the last cervical and first dorsal it is continued forwards as a bilaminar series of arched fibres, which are attached to the inner borders of each lateral tubercle of each cervical spine, and to the crest of the occipital bone as far as the occipital tuberosity. This portion of the septum is the *ligamentum nuchæ* (fig. 211), representing the structure of that name which is strong in heavy-headed animals. In man it consists of fascicles of mixed white and yellow fibres bound into a lamella by loose areolar tissue.

The **intertuberosus ligaments** are indistinct bands, which in the dorsal

region pass from tuberosity to tuberosity, with difficulty separable from the *multifidus* tendons (fig. 212). In the cervical region they are loose bands of connective tissue on the backs of the capsules.

There are no intertransverse ligaments. Those so called in the lumbar and cervical regions are intercostal, the dorsal are intertuberosus.

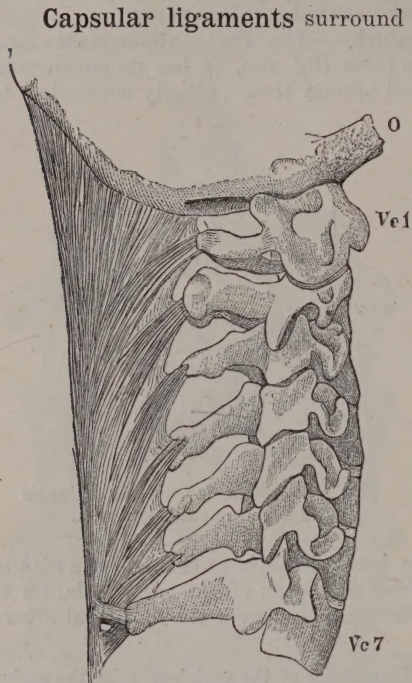


Fig. 211.—Ligamentum nuchæ extending from the occiput (O) to the seventh cervical spine.

the rib-head on the other. This union is strengthened by anterior and posterior accessory ligaments.

The anterior or **stellate ligament** consists of fibres radiating from the anterior margin of the head of each rib to the side of the body of the vertebra above, to the front of the intervertebral substance, as well as to the front of the vertebra with which the rib articulates.

The **posterior accessory ligament** (*posterior costo-vertebral* or *ligamentum colli*) consists of horizontally disposed, nearly transverse fibres filling the interval between the front of the transverse process and the rough surface on the back of the neck of the rib. For the first rib this is double.

Costo-transverse joint.—The tubercle of the first rib is tied to the transverse process of the first vertebra by a **costo-transverse capsular ligament** around the cartilage-clad articular surfaces. For this joint there is a strong accessory **posterior costo-transverse ligament** (fig. 212) from the outer border of the tuberosity to the outer edge of the tubercle of the rib.

The **double costo-vertebral joints.**—In the joints between the rib-heads and the vertebrae from the second to the ninth, the capsule includes two synovial membranes (fig. 204, 9) separated by a fibro-cartilaginous **interarti-**

Capsular ligaments surround the articular surfaces (fig. 172, 5), they are strongest in the lumbar region, where the outer surface of the interlaminar forms its inner part. Each capsule is strengthened here by a strong *upper* and a wide radiating *lower accessory band*, the latter extending to the lateral ridge of the spine. The dorsal capsules are not so tense, but their inner halves are made by the interlaminar ligaments. In the cervical region the interlaminar makes a very small part of the capsule, which is weaker and looser than elsewhere.

77. ARTICULATIONS OF THE RIBS.—The ligaments whereby the ribs are held in their places are three-fold—*costo-vertebral*, *intercostal*, and *costo-sternal*.

As these differ for the different ribs, those uniting the first, second, sixth, eleventh, and twelfth ribs to the vertebrae and the attachments of the rib cartilages to the sternum, should be dissected and examined.

The single costo-vertebral joints.—The costo-vertebral joints are single for the first, tenth, eleventh, and twelfth ribs, each of which has a single capsule (fig. 213) attached round the vertebral articular facet on one side and

ular ligament, passing horizontally from the intervertebral substance to the *crista capituli*. Each joint has *stellate* (ib., 10) and *posterior accessory* costo-vertebral ligaments (fig. 214) like those of the first rib, the former attached to the vertebræ above and below, the latter being double in the upper five joints, the second stratum being below, attached to the lower crest on the rib neck (*ligamentum costæ colli inferius*—fig. 198). The costo-transverse joints resemble that of the first rib.

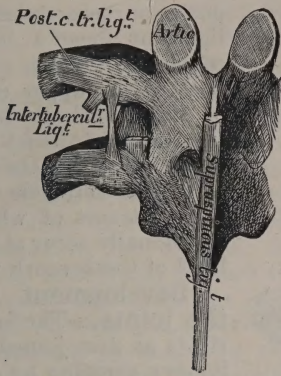


Fig. 212.—Dorsal view of the sixth and seventh dorsal vertebrae, showing the supraspinous and intertuberos ligaments.

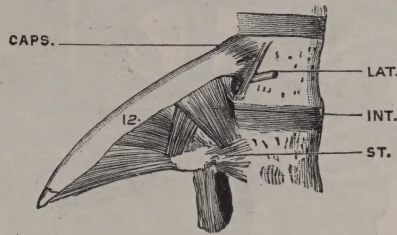


Fig. 213.—Articulation of the twelfth rib with its vertebra.

Superior costo-transverse ligaments.—For all the ribs below the first, the inner border of the *internal intercostal aponeurosis* is strengthened to form a series of accessory ligaments, which run from the transverse process above to the rib below (fig. 204, 11). There are two such sets of *superior costo-transverse ligaments*. The anterior is the stronger and its fibres pass downwards

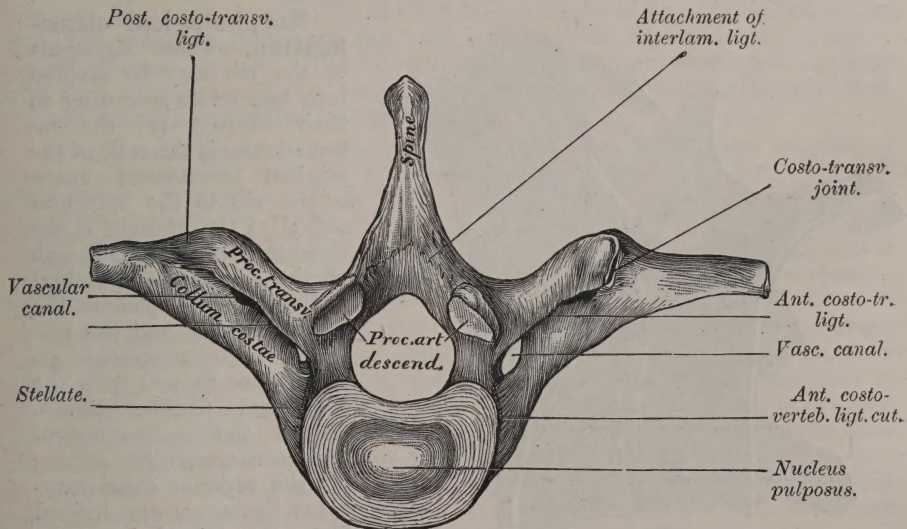


Fig. 214.—Third dorsal vertebra and ribs seen from below.

and inwards from the anterior inferior edge of the transverse process to the *crista superior* of the rib-neck below. They underlie the anterior branches of the intercostal vessels and nerves. The posterior, which is weaker, consists

usually of two fascicles, inner and outer, passing from the lower and back part of the transverse process to the neck of the rib above the *crista media*.

Ligamentum conjugale.—In many mammals the upper fibres of the

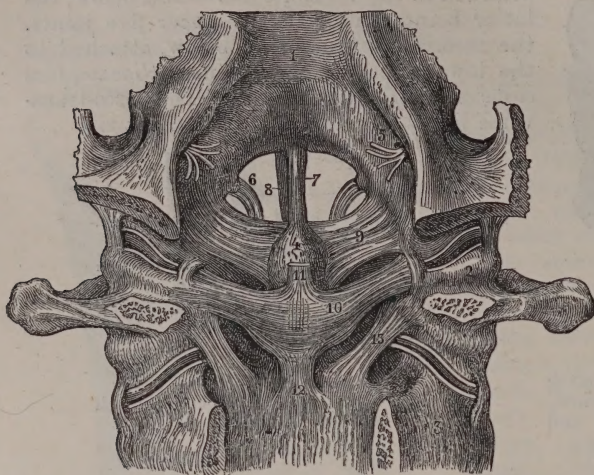


Fig. 215.—Occipito-atlantic and atlanto-axial joints seen from behind—3, axis; 5, hypoglossal nerves; 8, middle slip of anterior ligament.

the former the cavity does not appear until the seventh month. The tuberculo-transverse synovial cavity is distinct at the sixth month.

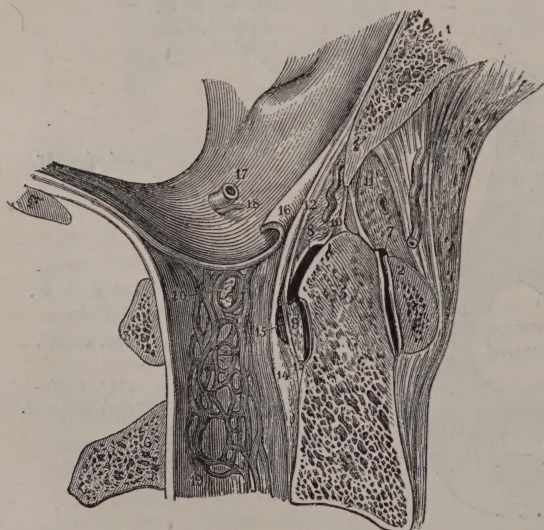


Fig. 216.—Sagittal section of occipito-vertebral joint—1, basilar process; 2, anterior arch of atlas; 5, odontoid process; 7, anterior occipito-atlantic ligament; 9, transverse ligament cut across; 14, ligamentum latum axiale. The synovial membranes and vertebral veins are shown.

posterior costo-vertebral ligament form a band continued across the back of the upper edge of the vertebral body from one rib to its fellow. These constitute the ligamentum conjugale costarum, traces of which occasionally occur at the head of the seventh rib.

Development of the joints.—The foetal rib is at first joined to its own vertebra by embryonic cartilage, to the vertebra above by embryonic connective tissue; in the latter, a synovial cavity develops early in the fifth month, that of the second rib first appearing, while in

Morphological classification.—These ligaments of the rib may be divided into four series according to their sources—(1) the interarticular is the relic of the original mesoblastic union of the rib to the vertebral axis; (2) the stellate is derived from the fibrous sheath of the column of vertebral bodies; (3) the capsulars, the *ligamenta colli*, and the posterior costo-transverse accessory are formed from the condensed fibrillar tissues around the costo-vertebral and costo-transverse joints; (4) the superior costo-transverse ligaments are derived from the lateral intermuscular septa.

In the cervical region the ankylosed costal processes show rudiments of the stellate ligaments (fig. 208, e), while the third series are ossified to form the costo-transverse lamella (p. 101).

In the lumbar region the stellate ligaments are very well marked (fig. 213, **ST**), and a system of intercostal and transverse costal bands represent the fourth series.

The intercostal ligaments are degenerated portions of the intercostal muscles or of their sheath. They are very distinct in the lumbar region between the costal processes (§ 195).

78. COSTO-STERNAL JOINTS.—The first costo-sternal joint is a synchondrosis, the cartilage of the first rib being continuous into a depressed area of the sternum. The second rib has two flat-faced articular surfaces and two synovial cavities between it and the pre-mesosternal lateral edge. Between these cavities is an interarticular fibro-cartilage, continuous with the rib on one side and the sternum on the other. The third rib has but one synovial cavity, the cartilage of continuity linking it to the sternum being a thin layer below embedded in the capsule. The fourth and fifth have generally two small synovial membranes on each side of an intermediately continuous thin edge of cartilage. The sixth has a very small cavity above the cartilage, and the seventh is usually a synchondrosis. The periosteum forms for each a capsule, strengthened by radiating sterno-costal fibres on the anterior surface, those from the lower true ribs ascending on the front of the sternum.

The pre-mesosternal joint is a syndesmosis at birth, but by the age of four it has become a synchondrosis. It is strengthened in front by an anterior, behind by two parallel lateral posterior ligaments.

From the metasternum to the cartilage of the eighth rib runs on each side a **costo-xiphoid ligament**, the displaced intercostal ligament of this region.

79. OCCIPITO-ATLANTIC JOINT.—Correlated with the increased mobility of the upper cervical regions, special forms of the intervertebral ligaments unite the occipital bone to the atlas and axis. The anterior common ligament, interrupted by the anterior arch of the atlas, is continued upwards from it to the front lip of the foramen magnum, forming the **anterior occipito-atlantic ligament** (fig. 205), with a thick central band (8) and a lateral thinner part (7). The interlaminar ligaments are continued upwards (fig. 210), though modified as before noted, forming **posterior atlanto-axial** (6) and **atlanto-occipital** (*ib.*, 5) ligaments.

To see the other ligaments of this joint, remove the posterior interlaminar ligaments as well as the hinder arches of the atlas and axis, and the back of the occipital bone. The dura mater sheathing the spinal cord (fig. 216, 16) being dissected carefully off from the back of the cervical vertebrae, the upward continuation of the posterior common spinous ligament is seen ascending to the occiput. On removing this, a deeper lamella of considerable strength and width is exposed, segmented off from this ligament, ascending from the back of the body of the axis to the upper surface of the basilar process within the foramen magnum (**ligamentum latum axiale**—fig. 207, 8).

The **transverse ligament** (figs. 215, 10; 217, 7) lies beneath the broad axial ligament (fig. 215, 12), and passes across in the transverse groove on the back of the odontoid process from the one internal tuberosity of the atlas to the other. The surface of the ligament here is covered with a thin plate of white fibro-cartilage, while on the contiguous surface of the odontoid process there is a thin layer of elastic fibro-cartilage, and a synovial sac is interposed.

The transverse ligament is a very strong restraining band for the odontoid process, requiring a weight of 130 kilos. to rupture. It represents the **ligamentum conjugale** for the costal processes of the first cervical vertebra (fig. 217).

The transverse ligament is fixed in place by means of vertical bands, one of which (*crus superius*—fig. 215, 11) ascends from its upper border and bends forward on the top of the odontoid process to be lost on each side of it in the back of the anterior occipito-atlantic ligament, the other (*crus inferius*—fig. 215, 12) descends to be fixed to the back of the body of the axis.

80. OCCIPITO-ODONTOID LIGAMENTS.—Above the transverse ligament are two strong fascicles of white fibres, one on each side, each arising from the inside of one occipital condyle and inserted into the same side of the upper part of the odontoid process; these are the **odontoid** or **check ligaments** (fig. 215, 9), each of which is made tense by turning the head to the opposite side. Some fibres of these ligaments pass transversely across the odontoid process, either behind or above it, but unattached.

Suspensory ligament of the axis.—From the apex of the odontoid a slender fibro-cartilaginous cord ascends to the front border of the foramen magnum (figs. 215, 7; 216, 10). This is a rudimental and lengthened intervertebral disc within which a trace of the notochord persists longer than elsewhere.

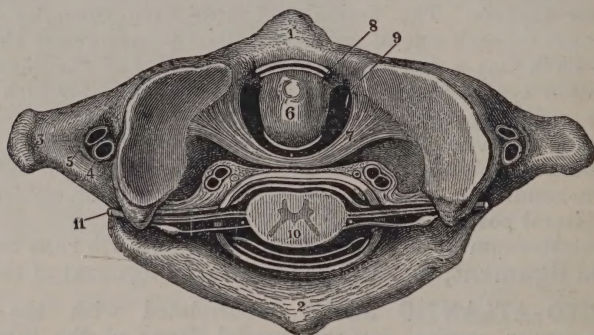


Fig. 217.—Horizontal section of the occipito-atlantic joint—1, anterior arch of atlas; 2, posterior arch; 3, end of transverse process; 4, costal process; 6, odontoid process; 11, sub-occipital nerve.

Besides these, the articular surfaces of the occiput and atlas (figs. 207, 7; 215, 2) are united by capsular ligaments, stronger anteriorly and laterally than behind and internally. Similar but much looser capsules surround the atlanto-axial joints (figs. 205, 6; 215, 13). These articular surfaces are in series with the rib-head joints, not with the other intervertebral articulations.

The synovial membranes of these joints are richly clad with villi. That between the odontoid and the anterior arch of the atlas extends upwards by a pointed process in front of the ligamentum suspensorium, sometimes it touches, and occasionally it communicates with some of the neighbouring sacs.

81. FUNCTION OF THE VERTEBRAL COLUMN.—The vertebral column has a three-fold function: 1st, it is the strong-walled canal guarding a nerve centre; 2nd, it is the basis from which the trunk muscles act; 3rd, it is the pillar of support, bearing on its summit the head, laterally the arms, and anteriorly the viscera. Its length, measured along its axis, varies little in well-formed persons, averaging 69 cm. in the adult male, in the female 67.5.

82. GENERAL CHARACTERS OF THE VERTEBRAL COLUMN.—Viewed in front the vertebral bodies increase in width from the axis to the first dorsal, decrease thence to the fourth dorsal, and increase again to the fifth lumbar, diminishing finally to the coccyx. These four taperings are the **pyramids of the spine**. When the ribs are removed from the dorsal vertebrae, the out-jutting transverse and lateral processes are widest at the atlas, first dorsal, and fourth lumbar, narrowest at the third cervical and last dorsal.

Viewed from behind the central row of spines projects medially, not always in perfectly even succession; those of the axis, the seventh cervical and the lumbar projecting most prominently. On each side of the spine is the

vertebral groove for the lateral vertebral muscles, floored for the most part by the bony laminae, between which wide gaps occur only in the first and twenty-fifth interspaces.

Viewed laterally (fig. 169) the spine shows that the bodies increase in size regularly from above downwards, forming an elongated cone. Behind the bodies are the twenty-five intervertebral foramina for the exits of the nerves. The lateral outline of the spine is sinuously curved; a line from the anterior arch of the atlas to the coccyx cuts the front wall of the column in five points. In the erect position of the body, the line of the centre of gravity passes through the vertebral column from the odontoid process cutting the front of the body of the second dorsal, the middle of the last dorsal, and the edge of the last lumbar vertebra.

The line of curvature should be measured along the vertical axis of the vertebral cone, but is often taken along the fronts of the bodies. The amounts and forms of the described curves will vary accordingly. The primary curve is the dorsal curve of accommodation, concave forwards, the remains of the primitive embryonic curve, and present from the earliest period. The sacral curve is also a curve of accommodation for the pelvic viscera, and appears about the fifth month of foetal life. The intervening lumbar curve begins as a small sacro-vertebral angle between these and gradually develops, increasing principally with the pushing back of the pelvis consequent on the extension of the lower limbs. The cervical curve is largely consequent on the extension of the neck, and like the lumbar is a curve of compensation. In these latter cases the amount of the curvature is dependent on the erect position of the body, and as growth proceeds the bodies of the vertebrae, intervertebral discs, and arches become moulded thereby. In the adult the curves are maintained (1) by the tension of the inter-laminar and interspinous ligaments; (2) by the shapes of the intervertebral discs, higher behind in the dorsal, higher in front in the cervical and lumbar regions; (3) by the shapes of the bodies, higher in front in the cervical and lumbar, higher behind in the dorsal.

The cervical curve extends from the atlas to the disc between the second and third dorsal, culminating at the body of the fifth cervical vertebra. The dorsal extends to the disc between the twelfth dorsal and first lumbar in the male, or to the centre of the twelfth dorsal in the female. The lumbar curve extends to the promontory of the sacrum, culminating in males in the body of the fourth, in females in the disc between the third and fourth.

These curves serve to break shocks in violent motions of the body, and to diminish the lengths of the bending elements of the column under vertical pressure. An elastic column, acted on by a terminal weight, is liable first to bend and then to break at the point of greatest flexure, and the breaking weight is inversely proportional to the square of the length of the column. By introducing so many points of flexure and thus shortening the component segments of the column, a commensurate advantage is gained.

The weakest point in the column is between the second and third cervical vertebrae; the point most exposed to injury is the union of the dorsal and lumbar curves, where the column of the trunk is the most movable, has the least transverse width, and is acted on by longer leverage than elsewhere. The twelfth dorsal vertebra is consequently the most liable to disease and injury.

The column can bear without crushing a terminal weight of 350 kilos. Its tearing limit at its weakest point averages 140 kilos.

The vertebral column has a slight lateral curve in the upper dorsal region, which is present even in early embryonic life, but is intensified by the greater use of the right arm and the greater weight of the viscera of the right side. This and the vertical curves are liable to much modification in different handicrafts as well as at different ages, in different races, and in the two sexes.

Motion between any two vertebrae is extremely slight, but the sum of these in the whole column amounts to an appreciable range. The amount of motion varies in different regions of the column and in different individuals, and can be increased almost indefinitely by early acrobatic training.

The weight of the head and arms during the day increases the curve of the upper dorsal and lumbar region, and to some extent compresses and diminishes the height of the discs; consequently the recumbent stature, or that on rising, averages in the young adult 11 mm. greater than the height in the evening. The amount of the lumbar curve varies during recumbency with the degree of extension of the hip-joint.

The spinal canal is sinuous, and varies in calibre and section at different points; but alterations of curve or the extremes of normal motion do not much affect its calibre at any point.

The principal sexual variations in the column, besides those above referred to, are the

greater length of the lumbar curve in females, the greater lumbo-sacral angle in females, the general size of the processes in the male, and the varying shape of the sacrum.

The proportional lengths of the different parts of the column are as follows, measured along the fronts of the curvatures. In the first column are given the average measurements in mm. taken along the fronts of the bodies, in the second the proportional part formed by each region, the whole spine being taken as 100 :—

	WHOLE SPINE	CERVICAL.		DORSAL.		LUMBAR.		SACRAL.	
		Average Actual.	Pro- portional.	Average Actual.	Pro- portional.	Average Actual.	Pro- portional.	Average Actual.	Pro- portional.
Fœtus 85 mm. (12th week),	100	8	20	18	45	9	22	5	13
„ 180 mm. (18th week),	100	15	19	34	42	17	22	14	17
„ 270 mm. (6th month),	100	22	20	45	41	27	24	16	14
Infant at birth, . . .	100	43	21	80	39	52	25	30	14
Child of 4, . . .	100	55	17	128	39	76	23	70	21
Adult man, . . .	100	125	16	310	40	190	25	137	19
Adult woman, . . .	100	120	16	290	39	190	25	145	19

The average and proportional size of each vertebra is as follows :—

No.	Weight in grms.	Height index of body.	Breadth index.	No.	Weight in grms.	Height index of body.	Breadth index.
		Post. height $\times 100$ ant. height.	Sagittal $\times 100$ transverse.			Post. height $\times 100$ ant. height.	Sagittal $\times 100$ transverse.
C. {	1	5.7	—	D. {	13	12.8	117
	2	6.7	—		14	14.2	116
	3	7.0	100		15	15.4	110
	4	7.4	99.9		16	16.3	105
	5	7.5	100		17	18.3	M. 104 F. 91
	6	8	100		18	19.8	108 107
	7	9.9	99.8		19	21.4	110 107
D. {	8	11.7	104	L. {	20	26.4	108.8 104.9
	9	11.8	100		21	36.1	103 101.4
	10	11.0	106		22	33.0	99.1 96.2
	11	11.6	106		23	32.0	95 91
	12	11.8	111		24	32.4	82 80

Owing to the varying obliquities of the spines the tips palpable on the surface are not opposite the corresponding bodies.

The spine of the axis is on the level of the body of the third, that of the third on that of the fourth, the fourth on the level of the disc between fourth and fifth, the fifth on the level of the disc between fifth and sixth, the sixth and seventh are opposite their own bodies; the first dorsal is opposite the disc between the first and second, the second is opposite the body of the third, the fourth on the level of the disc between the fifth and sixth, the fifth, sixth, seventh, and eighth opposite the seventh, eighth, ninth, and tenth respectively, the ninth is opposite the body of the tenth, the tenth opposite that of the eleventh, and the eleventh opposite the disc between the eleventh and twelfth. The third and fourth lumbar are opposite their respective bodies, and the fifth spine is opposite the disc between the fourth and fifth.

The chief race-characters are the diminution of the lumbar and sacral curves and the diminished breadth of the sacrum in lower races.

83. THORAX.—The thorax is somewhat conical, sagittally compressed, with a narrow upper opening, whose plane looks upwards and forwards, and a wide lower aperture whose plane looks forwards and downwards. It has a long posterior wall formed of the vertebræ and angles of the ribs, and a short anterior wall formed of the sternum and rib cartilages. The upper opening is kidney-shaped, measuring about 9 cm. transversely, 5 cm. sagittally, and is occupied by the apices of the lungs, the trachea, œsophagus, thoracic duct, and the vessels of the neck and arms, together with the phrenic, vagus, sympathetic, cardiac, and first dorsal nerves, and the anterior spinal muscles, as well as the internal mammary and superior intercostal arteries and veins, and the *sterno-hyoid* and *sterno-thyroid* muscles. The margin of the base, formed by the lower edge of the false ribs, is a curved ascending line, meeting its fellow anteriorly at an angle, the *subcostal angle*, into which the metasternum projects. The thorax is shorter and wider when undistorted by stays in the female than in the male, is deeper sagittally than transversely in the young fetus, but widens transversely after birth, reaching its maximum of development about the twenty-fifth year. The thoracic index, taken at its widest part, $\frac{\text{sagittal} \times 100}{\text{transverse}}$, varies in different races. The

thorax contains the heart and lungs, and is subject to momentary alterations in capacity during respiration, enlargement taking place by the rotation of the ribs around the back-and-outward-running axis of their necks. The costo-vertebral articulation only allows this one motion of rotation, but the ribs are so remarkably curved that this slight rotation of the end produces not only an elevation of the anterior extremity, but an eversion of the rib, thus enlarging the cavity vertically, sagittally, and transversely; the sternum becomes raised and its obliquity increased thereby, the first rib moving as do the others. As the transverse processes of the dorsal vertebræ increase in obliquity from above downwards, so the obliquity of each rib-neck increases, and the amount of motion likewise increases from above downwards; with this increase there is a slight alteration in the nature of the angular motion.

During life the thorax is a closed cavity, and the intrathoracic viscera communicate by open tubes with extrathoracic spaces; so in enlargement of the cavity the increased internal space is occupied by the rush thereinto of the air into the air passages, and of blood in the inferent blood-vessels. Expulsion of the superfluous contents take place when, by diminution of the cavity, the negative pressure in the air passages becomes positive.

The consideration of the cranial part of the axial skeleton had better be postponed until the student has learned the bones of the limbs.

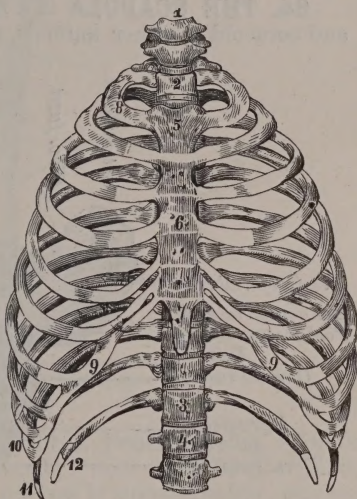


Fig. 218.—Front view of the skeleton of the thorax — 1, sixth cervical vertebra; 2, first dorsal vertebra; 3, last dorsal vertebra; 4, first lumbar; 5, presternum; 6, mesosternum; 7, metasternum; 8, first rib; 9, seventh rib; 10, 11, 12, tenth, eleventh, and twelfth ribs.

APPENDICULAR SKELETON.

The bones of the upper limb are divisible into four groups :—

1. The shoulder girdle—clavicle and scapula.
2. The upper arm—humerus.
3. The forearm—radius and ulna.
4. The hand—eight carpals, forming the wrist ;
five metacarpals, forming the palm ;
fourteen phalanges, three in each finger, two in the thumb ;
two sesamoid bones at the base of the first thumb-phalanx.

84. THE SCAPULA is a flattish triangular bone representing the scapula and coracoid of other animals, placed on the posterior surfaces of the ribs from

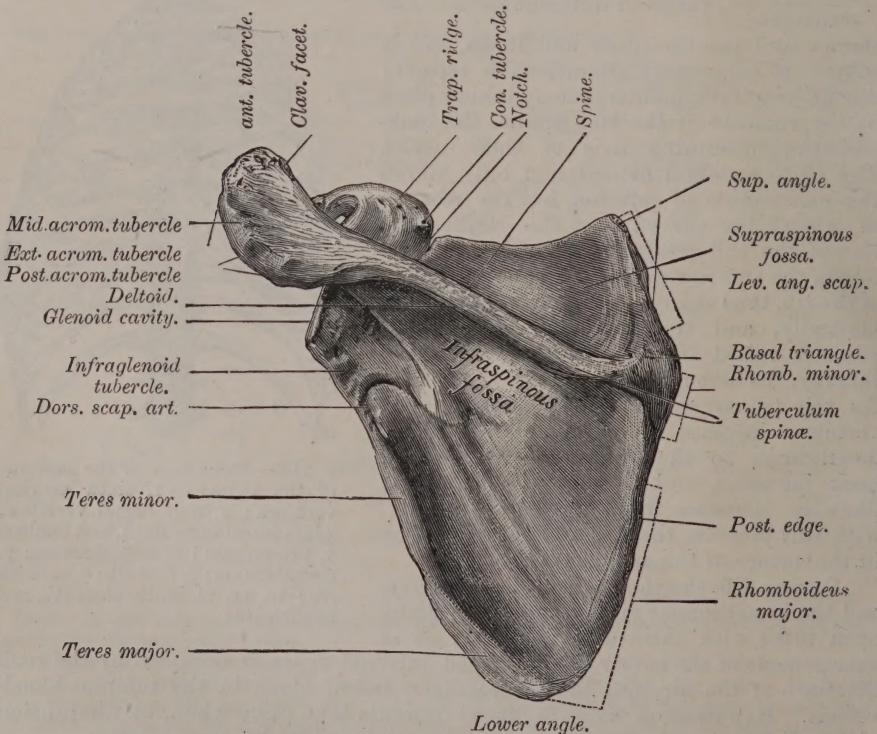


Fig. 219.—Dorsal surface of left scapula, $\frac{2}{3}$.

the second to the seventh, from which it is separated by the *serratus magnus* muscle and areolar tissue. It has three **edges** (fig. 219)—a short, sharp, concave **upper**, a long convex **posterior**, and a thick **outer** or axillary ;

three **angles**—a thin sharp **upper**, a long rounded **lower**, and a thick **outer** or articular; and two **surfaces**—an **anterior** concave lying on the thorax and a **posterior** convex, divided by a strong ridge, the **spine**, into two fossæ, a **supraspinous** and an **infraspinous**.

The upper edge is thin and its outer half gives origin to the *omo-hyoid* muscle (fig. 220, *o.h.*). Externally it is interrupted by the suprascapular notch, which transmits the suprascapular nerve and is bridged by a ligament (fig. 223).

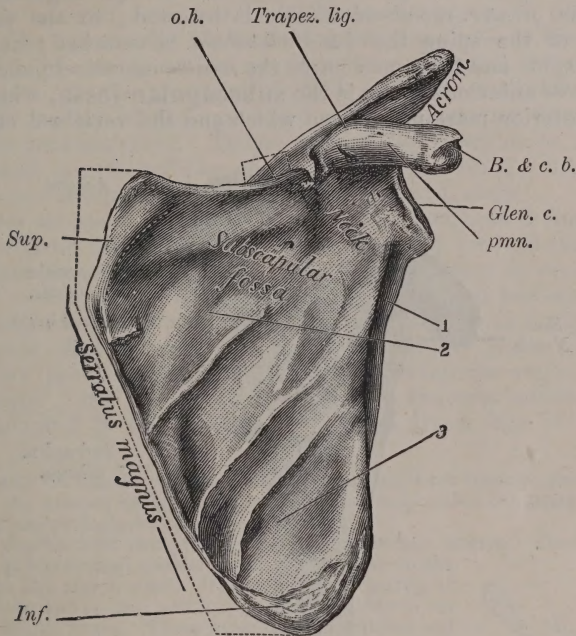


Fig. 220.—Ventral surface of left scapula, $\frac{2}{3}$.

External to this is the flattened, hook-like **coracoid process** (*cor.*), “like a finger, half-bent, pointing forwards and outwards” over the shoulder-joint, palpable during life below the clavicle. This process is smooth below, marked above by an indistinct tubercle behind and by a ridge in front for the conoid and trapezoid ligaments, which tie it to the overlying clavicle. Its inner border gives insertion to the *lesser pectoral* (fig. 220, *pmn.*), its outer to the coraco-acromial ligament (fig. 224). From its tip arises the common tendon of the *biceps* and *coraco-brachialis* muscles (*B. & c. b.*).

The shallow oval **glenoid cavity** (*Glen. c.*) at the outer angle is separated by a slight *sub-coracoid notch* from the root of the coracoid process. This socket for the humerus is vertically elongated, its breadth at its lower third being 0.7 of its height; at its upper third 0.5. Its front lip is notched above, and its face looks outwards, forwards, and a little upwards. Above it, is a slight **supraglenoid tubercle** (fig. 221), included in the recent state within the capsule of the shoulder-joint, and giving origin to the long tendon of the *biceps* (fig. 119, *L.*). Below the cavity is a longer rough **infraglenoid tubercle**, which is extra-articular, and gives origin to the long head of the *triceps*.

The outer edge below this tubercle presents two lips (fig. 221), one sharp,

irregular, and posterior (fig. 220, 1), crossed above by a groove for the dorsal scapular artery; and a second rounded and anterior. Between these a portion of the *subscapularis* arises.

The **inferior angle** is the most acute, though thick and rounded. From it the hinder or **vertebral edge** ascends, lying about 5 cm. from the spinal column, to which it is closer above than below. This border is irregularly convex, projecting at one spot near its upper third, where the spine of the scapula begins. Into the border between the inferior angle and the level of the spine the *greater rhomboid* muscle is inserted; to the projecting edge at the back of the spine the *lesser rhomboid* is attached; and to the edge between the spine and the upper angle the *levator anguli scapulae*.

The concave anterior surface is the **subscapular fossa**, which has usually a definite posterior margin, between which and the vertebral edge is a linear

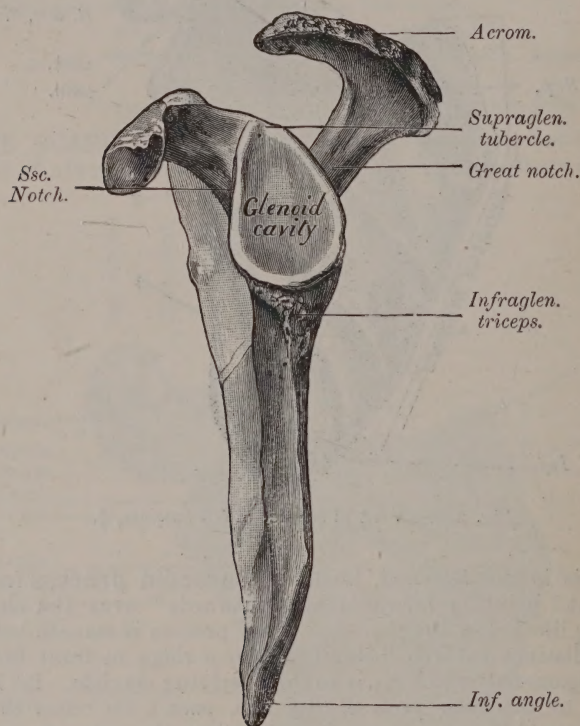


Fig. 221.—External margin of left scapula, the glenoid cavity, and axillary edge, $\frac{1}{2}$.

area into which the *serratus magnus* is inserted, dilated above at the superior angle into a flat triangular surface (fig. 220, *sup.*), and below into a rough elongated patch (*ib.*, *inf.*).

The floor of the fossa presents three or four ridges ascending from the hinder margin, giving origin to the four tendinous planes of the *subscapularis* while the fleshy fibres of the muscle occupy the hollows between. The muscle lies on, but is not attached to the outer third of the fossa.

On the dorsal surface of the scapula (fig. 219) the **spine** projects between the two fossae, towards which its upper and lower slightly hollowed surfaces are respectively directed. Its posterior surface is narrow, rough, and sinuous,

and can be felt through the skin. It commences at the hinder edge in a **basal triangle**, over which the tendon of the *trapezius* glides. At its hinder third is the thickened **tuberculum spinæ**, in front of which this surface first narrows and then widens, expanding ultimately into the flat quadrate **acromion process**, which is twisted somewhat forwards so as to overhang the shoulder-joint (fig. 221). The under side of this process is smooth and bursa-lined; the upper surface is flat, rough, and subcutaneous, continuous with the narrow posterior surface of the spine. Into the upper edge of the spine and acromion the *trapezius* is inserted, its lower dorsal fibres converging to the tuberculum spinæ. From the lower edge the *deltoid* arises, beginning at the tuberculum. The outer edge of the acromion presents four marginal tubercles for the tendinous origins of the acromial deltoid. These muscular attachments encroach on the surface of the spine and acromion, leaving very little of the bone uncovered between them. To the apex of the acromion (*a*, *t*), the coraco-acromial ligament is attached (fig. 224). Behind this on the inner margin is an elliptical articular **facet for the clavicle** (fig. 219, *clav*).

Beneath the acromion the base of the spine is separated from the edge of the glenoid cavity by the **great scapular notch** (fig. 221), whereby the supra- and infraspinous fossæ communicate. The former fossa is occupied by the *supraspinatus* muscle, which arises from its margins and posterior half (*s.sp*). The infraspinous fossa is much larger, and is marked by an irregular **oblique line**, which cuts off a narrow area along the axillary edge. This space is divided into two parts—a lower, wider, above the inferior angle, giving origin to the *teres major*; and an upper, narrower, for the *teres minor*. The rest of the fossa is occupied by the *infraspinatus*, which arises from its margins and posterior half.

Development.—A line drawn from the suprascapular notch through the great scapular notch, isolating the glenoid cavity and coracoid process, is called the **neck** of the scapula, but this is not of morphological importance (fig. 220).

The scapula ossifies from two primary and five secondary centres. The body and spine ossify from one sub-periosteal centre, which begins close to the glenoid cavity in the eighth week. The acromion is gristly at birth, and ossifies by two centres which appear respectively in the fifteenth and sixteenth years. These unite before eighteen, and join the spine about nineteen, but one may remain detached (fig. 225, *os. ac*). A very small marginal area at the lower end of the hinder edge, representing a *superscapula*, remains cartilaginous longer than any other part of the bone, and ossifies by a separate centre about twenty. A second centre may appear at the inferior angle at twenty.

The coracoid element includes the top of the glenoid cavity and the supraglenoid tubercle, as well as the process. It is cartilaginous at birth, but a bony entochondral centre appears in it within the first year, and it joins the scapula at fourteen. A scale-like epiphysis appears on its surface at the trapezoid ridge about fourteen, which consolidates at eighteen. Very often a minute epiphysis appears in the glenoid border of the coracoid at seven, which, it has been conjectured, may represent the true coracoid, while in that case the bulk of the process would be a modified epicoracoid.

The young scapula consists of two layers of compact bone separated by an intervening cancellous lamella. In the adult the middle layer disappears in the floor of the supra- and infraspinous fossæ, and the bone becomes thin and translucent in spots.

The periosteum is strong and laminated, especially on the spine, acromion and coracoid, and along the margins. The bone is pierced on the concave surface by nutrient branches of the subscapular artery, and on the convex side above and below the spine by branches of the suprascapular artery.

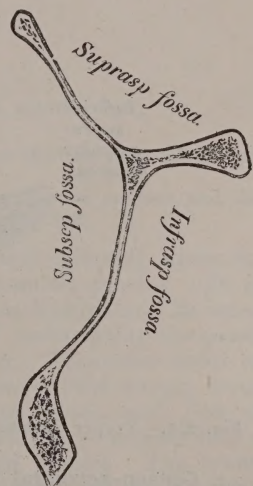


Fig. 222.—Sagittal section of left scapula.

The scapula may be considered as consisting of an axis running from the basal triangle to the glenoid cavity, from which three lamellæ diverge at different angles, a *prescapula* above, forming the floor of the supraspinous fossa, a *mesoscapula* or spine and a *postscapula* below (fig. 222). The angle between the pre- and mesoscapula is about 100° ; between the meso- and postscapula 130° ; and between the pre- and postscapula 130° . The deepest part of each fossa is along the axial line. In the position of rest the middle of the glenoid cavity is on the level of fourth dorsal vertebra.

The scapula glides on the wall of the thorax, and its motion is limited by the clavicle as a radius; its inferior angle lies in a pocket formed by the latissimus dorsi, and can move through a space of 3 cm. vertically and 3.7 cm. transversely. The chief human peculiarity is the long postscapula, a character which increases from childhood to adult life; the scapular index ($\frac{\text{breadth} \times 100}{\text{height}}$) at the fifth month being 92; at birth, 88; at fourteen years, 78; in the adult about 70. The index is lower in Europeans than in the dark races, and in males than females. The scapula articulates with two bones, gives origin to ten muscles and insertion to six.

85. PROPER LIGAMENTS of the scapula are fibrous bands stretched from one part of the bone to another. These are:—

1. **Suprascapular** (fig. 223), consisting of two slips from the upper edge to the root of the coracoid, bridging the notch.

Under the upper, stronger, dorsal band passes the suprascapular nerve, over it the suprascapular artery; beneath the weaker, lower, ventral and more obliquely ascending band (fig. 225) is a small vein. The origin of the *omo-hyoid* is on a plane between these.

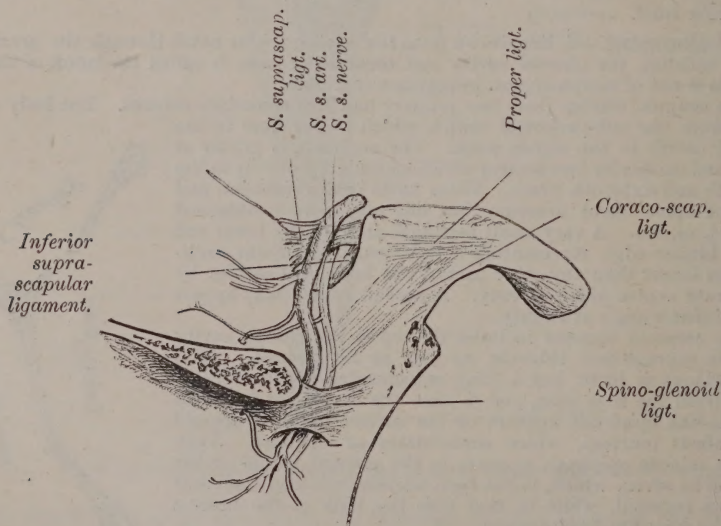


Fig. 223.—Proper ligaments of right scapula; dorsal surface, the acromion process cut off.

2. **Coraco-acromial** (fig. 224, Cal.), strong and triangular, attached by its apex to the acromion on the inner side of its tip, by its base to the outer edge of the coracoid process. This ligament consists of a strong posterior oblique and a strong anterior transverse band. Its free anterior edge thins into an expansion on the front of the shoulder-joint (*ib.*, Semiv.); its hinder edge joins the supraspinous fascia.

A crescentic deficiency exists in the weak middle part at its coracoid border, through which in about 14 per cent. of shoulders a slip of the *lesser pectoral* tendon is continued.

3. **Coraco-glenoid**, a weak band beneath the last, from the edge of the crescentic

deficiency (fig. 224) to the edge of the glenoid cavity; the remains of the sheath of the prolonged pectoral tendon.

4. **Coraco-scapular** (fig. 223), rudimental glistening fibrous bands blended with the periosteum over the coraco-scapular synostosis. These bands are remains of the original coraco-scapular ligamentous system.

5. **Spino-glenoid** (fig. 223), a thin skew-layer of areolar tissue bridging the great scapular notch over the infraspinous vessels and nerves, stretched from the outer edge of

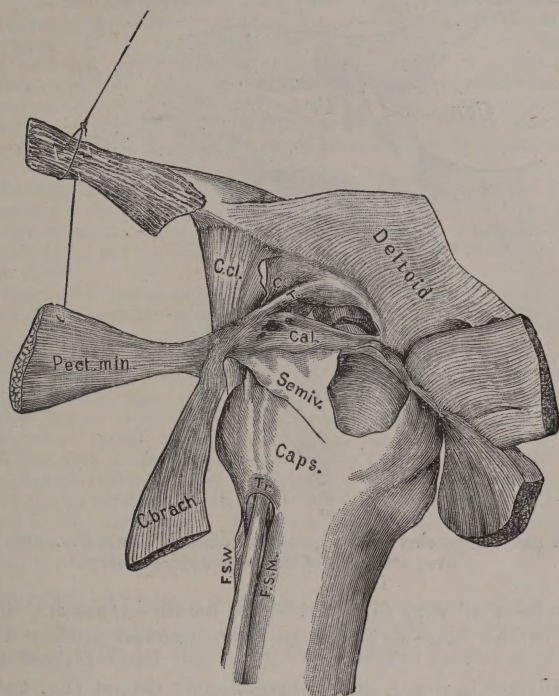


Fig. 224.—Coraco-acromial ligament and its relations, anterior view.

the spine to the glenoid cavity under cover of the *infraspinatus* tendon, from the sheath of which it is derived.

Other bands, such as the sling insertions of the *rhomboid* and *serratus magnus*, and the cervical band shown in fig. 225, may also be enumerated in this connection.

86. THE COLLAR BONE OR CLAVICLE stretches obliquely upwards, backwards, and outwards from the sternum to the acromion process. It is curved like an italic *f*, with its inner concavity directed backwards and its outer forwards. Its outer or **acromial end** bears a terminal, transversely elongated and rarely smooth facet to articulate with the acromion. The outer third of the clavicle is flattened above and presents a rough concave front margin, from which the *deltoid* muscle arises, and a convex hinder edge, which, with part of the adjoining upper surface, gives insertion to the *trapezius*, and projects into a prominent **coracoid angle** which overlies the coracoid process. The lower surface of this angle is a rough **conoid tubercle**, from which a short coarse **trapezoid ridge** runs outwards and forwards. These give attachment to the coraco-clavicular ligaments (fig. 225).

For its inner two-thirds the clavicle is rounder, and its back-directed concavity arches over the subclavian vessels and the brachial nerves. Its upper surface is covered by little more than skin which glides loosely over it.

The anterior margin for about the inner half is roughened to give origin to the *great pectoral*, and the upper edge for the inner fourth to the *cleido-mastoid*. The inner terminal **sternal facet** is irregularly triangular, with its apex backwards, and is placed obliquely, looking downwards and inwards, and arti-

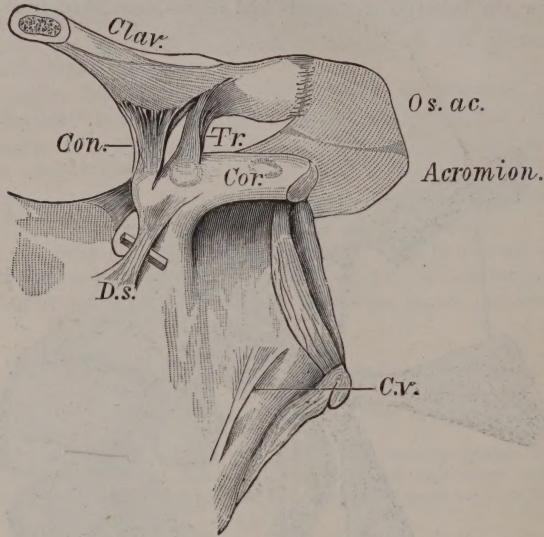


Fig. 225.—Proper and coraco-clavicular ligaments, internal view—*C.v.*, cervical band arching over a branch of the subscapular artery.

culating with a facet of very different shape on the sternum. From the lower and back part of the bone external to this articular surface the *sterno-hyoid* muscle arises.

The lower surface is rough and conspicuously ridged (fig. 226). Internally where it overlies the cartilage of the first rib, there is a **costal tuberosity** for

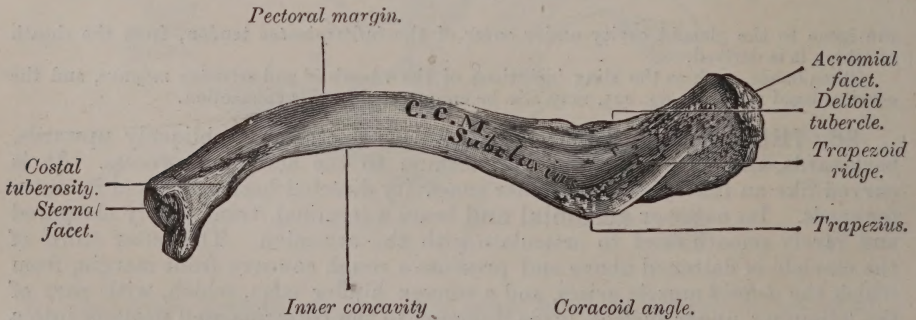


Fig. 226.—Left clavicle, under side— $\frac{1}{2}$.

the costo-clavicular ligament; external to which the surface is slightly channelled as far as the conoid tubercle for the insertion of the *subclavius* (**subclavian impression**). The costo-coracoid membrane is attached to the ridge in front of this sulcus (fig. 226, *C.C.M.*), and a layer of cervical fascia overlying the *omo-hyoid* muscle is attached to the ridge behind it.

The clavicle serves as a fixed basis of support for the scapula and through it for the arm, which is thereby enabled to perform definite motions. Its outer end can move through an arc of about 5 cm. vertically and about 6 cm. horizontally. In circumduction, the acromial end describes an ellipse with a major axis of 7 to 8 cm. and a minor axis of 5 to 6 cm. The inner curve in the male is very variable, but usually represents an arc of 70° of a circle 85 mm. in radius, in the female 70° of 72 mm. The outer part is seldom really curved, being a straight piece set on at an angle of 135° with the axis of the rest of the bone.

Structure.—The clavicle presents a thick outer compact layer and a cancellated interior whose primary planes in the shaft run from within outwards and forwards, and bound large coarse-meshed spaces. In the extremities the compact layer is thin and the intersecting lamellæ are the stronger, directed backwards and outwards in the sternal end, directly outwards in the acromial end. A set of chordal supplemental lamellæ underlie the compact matter at the greatest convexity of the inner curve. A recent clavicle contains red marrow, at its sternal end especially; it is pierced below by the nutrient branches of the supra-scapular and acromio-thoracic arteries. The periosteum is easily separated from the middle of the bone.

Of the two clavicles the right is generally the longer, stronger, and more curved. The female bone is smoother and less curved than the male. The roughness of the impressions varies with the development of the muscles, and the habitual occupation of the individual imprints its characters on the clavicle and the joints at each end of it more than on any other bone of the upper limb.

The deltoid impression begins at a slight *deltoid tubercle* and ends at the acromial facet. The ridge for the cleido-mastoid stops short of the sternal end. The clavicle articulates with three bones, gives origin to four muscles, and insertion to two.

Development.—The clavicle is a compound bone, being a dermal splint with which the pre-coracoid has become incorporated. It first appears as a streak of longish mesoblastic cells, shortly after the first trace of the upper limb has appeared at the end of the third week. Ossification begins in the fifth week, immediately after it has begun in the lower jaw, but proceeds more rapidly than in that bone. In front and behind the bony nucleus the tissue chondrifies, but ossification follows swiftly on the change into cartilage. In the eighth week the clavicle is 6 mm. long, equalling 0.2 of the cranio-coccygeal length; in the fifth month it is 0.19; at birth, 0.17; in the adult male, 0.16. At about sixteen a lamellar epiphysis appears in the cartilage of the sternal end, which consolidates at twenty-two. As this portion of the cartilage does not seem to be segmented from the rest, it is probable that this epiphysis is of little morphological value.

87. STERNO-CLAVICULAR JOINT.—The dissimilar articular surfaces of the sternum and the clavicle are harmonised by the intervention of an **inter-articular fibro-cartilage** (fig. 227), the modified *lateral episternum*, between

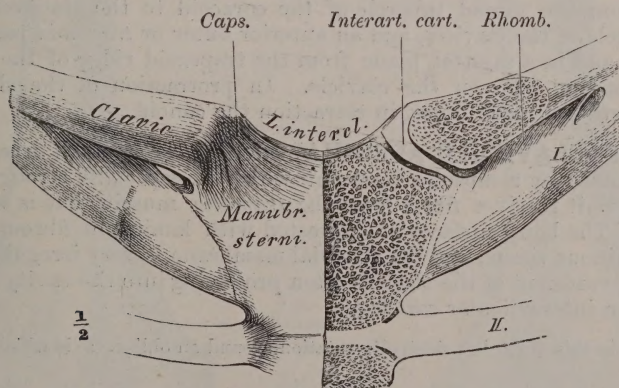


Fig. 227.—Sterno-clavicular joints, the left is coronally divided.

which and each bone there is a separate cavity whose synovial membranes present many processes and fringes. This is functionally a plane joint, and is protected by a continuous capsular ligament, composed chiefly of fibres ascending from the sternum to the clavicle and interarticular cartilage. This capsule is

strongest behind and in front, weakest below, and supplemented by two accessory ligaments, the interclavicular and the costo-clavicular.

Interclavicular ligament, a differentiation of the lower part of the cervical fascia, stretches from the upper and back part of the sternal end of the clavicle and capsular ligament of one side to the other, behind and between the *sterno-mastoid* muscles. Its thin upper edge, when cut from the fascia, is directed backwards and upwards. Below, it is connected to the top of the sternum on the plane of its hinder border, and behind it is separated by the *sterno-hyoid* and *-thyroid* muscles from the vessels of the neck. It limits depression of the clavicle, and when one clavicle is much depressed it draws the other upwards, a fact which should be borne in mind in fracture of this bone.

Costo-clavicular ligament (rhomboid ligament), strong and rhomboidal, ascends inwards from the cartilage of the first rib to the costal tuberosity of the clavicle, internal to and behind the *subclavius*, internal to and in front of the subclavian vein.

It is a differentiation of the sheath of the *subclavius* muscle, and limits elevation of the clavicle.

The **interarticular cartilage** is an irregular disc thicker above, and attached above and behind to the edge of the clavicle and capsular ligament, in front to the capsule alone, below to the cartilage of the first rib and to the sternum.

It consists of many lamellæ of fibres running in different directions, separated by sparingly disposed cartilage cells. The end of the clavicle is invested with fibro-cartilage, containing little islands of hyaline cartilage. Of the two synovial cavities the inner or menisco-sternal is the larger, the outer or menisco-clavicular is continued beneath the clavicle and on the cartilage of the first rib. Real rotation in this joint can only occur through 45°. The costo-clavicular ligament is directly opposed to the *trapezius* and limits its range of action.

88. THE CORACO-CLAVICULAR LIGAMENT (fig. 225) consists of two parts, artificially separable—a posterior, vertical or *conoid*, which ascends widening from the conoid tubercle of the coracoid to the transversely placed conoid tubercle of the clavicle, and an anterior outer or *trapezoid* passing nearly horizontally and in a sagittal plane from the trapezoid ridge of the coracoid to the corresponding line on the clavicle. In protraction of the shoulder the trapezoid portion is made tense, in retraction the conoid.

89. THE CLAVICULO-ACROMIAL JOINT is a small irregular plane joint surrounded by a capsular ligament which is especially strong above and in front where it receives fibres from the *trapezius* muscle, but is weak behind and below. The bony surfaces are invested with laminæ of fibrous and elastic fibro-cartilaginous tissue, and the synovial membrane is very irregular, processes of the soft investment of the clavicle often projecting into the cavity from above, simulating an interarticular cartilage.

Movement in this joint is principally rotation around an oblique axis which traverses its anterior third.

90. HUMERUS.—This is a long bone bearing at its proximal end a cartilage-clad **head**, nearly one-third of a sphere, which is directed upwards, backwards, and inwards to articulate with the glenoid cavity of the scapula. The line bounding the head is the **anatomical neck**, external to which is the outer or **greater tuberosity** (fig. 228, *G.t.*) marked by three impressions—upper, middle, and lower—for the insertions of the *supraspinatus* (*ib.*, *S*), *infraspinatus*, and *teres minor*. Anteriorly this is separated from the **lesser**

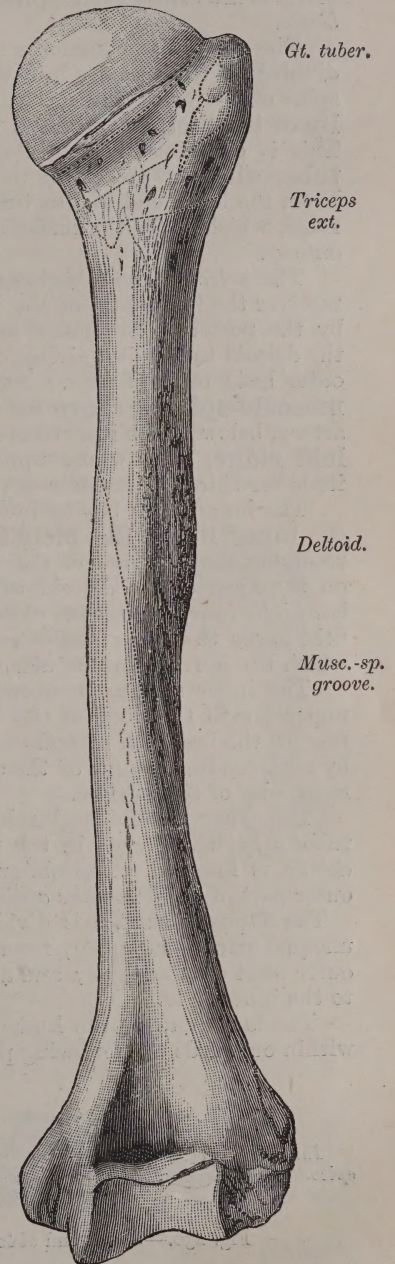
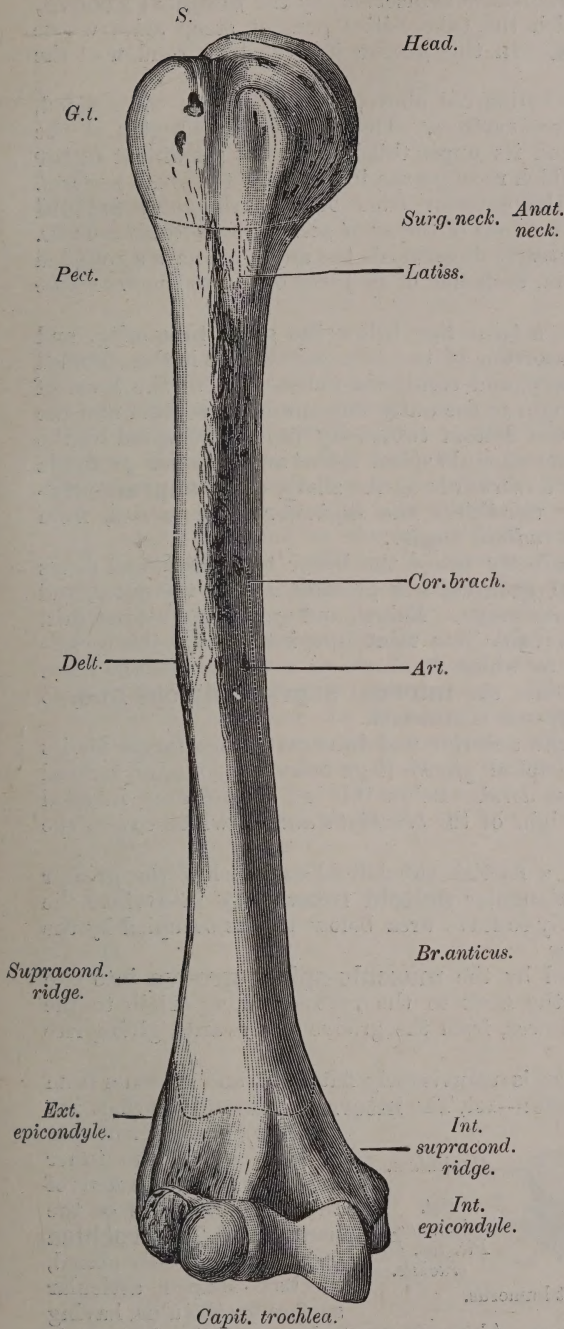


Fig. 228.—Right humerus, front view— $\frac{3}{4}$.

Fig. 229.—Right humerus, back view— $\frac{3}{4}$.

tuberosity into which the *subscapularis* is inserted, by the **bicipital groove**, a vertical furrow, towards which the tuberosities present steep sides whose margins are called their **spines**. In this groove lies the long tendon of the *biceps*.

The shaft of the humerus is cylindroid above, but below it is three sided, divided by three angles into three surfaces. The *anterior angle* begins at the spine of the great tuberosity, and its upper third forms the prominent **outer lip of the bicipital groove** which receives the insertion of the *great pectoral*. This is continued below into the anterior edge of the triangular **deltoid tuberosity** (*delt*) receiving the tendons of the *great pectoral* and *deltoid muscles*. From the lower end of this tuberosity downwards the angle becomes a rounded ridge, which, with the surfaces on each side of it, gives origin to the *brachialis anticus*.

The *external angle* begins as a faint line below the great tuberosity, and receives the lower part of the insertion of the *teres minor*. It is then crossed by the posterior circumflex artery, and continues indistinctly to the level of the deltoid tuberosity, giving origin to the outer intermuscular septum and the outer head of the *triceps*. At the deltoid tuberosity it is interrupted by the **musculo-spiral groove** for the musculo-spiral nerve and superior profunda artery, below which it continues downwards as the sharp, outer **supracondyloid ridge**, from whose upper two-thirds the *supinator longus* arises, from its lower third the *extensor carpi radialis longior*.

The *inner angle* begins indistinctly below the lesser tuberosity, and forms the **inner lip of the bicipital groove**, less prominent than the outer, and receiving the insertion of the *teres major*. Below, and on a plane behind this, on the level of the deltoid tuberosity, is a faint line, into which the *coraco-brachialis* (*c.br*) is inserted, close to which the *nutrient canal* pierces the bone. Still lower the inner angle becomes the **internal supracondyloid line**, to which the inner intermuscular septum is attached.

The inner surface between the anterior and internal angles forms for its upper fourth the floor of the bicipital groove (*b.g*), marked by a faint vertical line for the insertion of *latissimus dorsi*. Below this is a smooth area, invaded by an ascending tongue of the origin of the *brachialis anticus* which covers the remainder of this surface.

The outer surface begins by a flattish sub-deltoid area below the greater tuberosity, which ends in the triangular **deltoid tuberosity** into which the *deltoid* is inserted. The obliquely-concave area below this is occupied by the outer part of the *brachialis anticus*.

The posterior surface is divided by the **musculo-spiral groove** into two unequal parts—an upper, from the neck to the groove, giving origin to the outer head of the *triceps*; and a lower, from the groove downwards, giving rise to the inner head.

The lower end of the humerus is transversely flattened, and presents from within outwards the following parts:—1st, The **internal epicondyle** (figs. 228

and 230), a prominent spur at the end of the inner angle, for the attachment of the flexor muscles of the hand. 2nd, The **trochlea** (*tr*), a horizontally-placed, dicebox-shaped articular surface for the ulna, having



Fig. 230.—Lower end of left humerus.

its inner cone larger than the outer. Above its central constriction in front is the **coronoid fossa** (fig. 228, *c.f*), a shallow pit below the end of the anterior angle, occupied by the coronoid process of the ulna in flexion of the elbow.

Posteriorly there is a larger hollow, the **olecranon fossa** (fig. 229), whereinto the olecranon process of the ulna fits in extension. The bony floor between these fossæ is thin to translucency. 3rd, External to the trochlea on the front of the lower end is the **capitulum**, a segment of a small spheroid projecting forwards to articulate with the head of the radius. Above it there is a depression in front for the edge of the head of the radius in flexion. 4th, Outside this is the **external epicondyle** (*e.ep*), a short, rough process at the end of the outer supracondyloid ridge, giving origin to some of the extensors of the hand. This area extends behind the capitulum as far as the outer lip of the trochlea.

The transverse section of the average humeral head makes 135° of a circle of 27 mm. radius in the male, 23 mm. in the female; the vertical section makes 142° of a circle of 28 mm. radius. These are not simple circles, but the inner and outer, upper and lower, parts of each are arcs of circles of different radii, the outer and lower respectively belonging to circles of longer radii than the inner and upper. The encrusting cartilage is thicker medially than laterally, as on every articular head.

The term neck is applied to three parts of the humerus: the **anatomical neck** or space between the limit of the cartilaginous incrustation and the attachment of the capsule (fig. 229, *anat*); the **morphological neck** or area of union of head and shaft which corresponds only to the lower half of the plane of the head, inasmuch as the upper half corresponds to the union of the head and tuberosities. Before the union of the parts of the upper end the shaft terminates above in a low, three-sided pyramid, with its apex upwards and presenting three sharp arrises; the fore and hind isolate an inner surface which abuts on the head, while the two other surfaces underlie the tuberosities. The portion thus isolated supporting the head is of the same nature as the neck of the femur, and constitutes the morphological neck; its axis forms an angle of 130° with the shaft, and its terminal face forms an angle of 45° with the horizon. The **surgical neck** (fig. 228) is an indefinite area below the tuberosities and above the insertion of the great pectoral, in which the bone is liable to fracture.

No parts of the humerus, except the tips of the epicondyles, are subcutaneous. The greater tuberosity projects below the acromion under cover of the *deltoid*. The facets for the *spinati* muscles are flattish, that for the *teres minor* is irregular, as the lower part of the insertion is fleshy. Branches from the posterior circumflex artery pierce the greater tuberosity, several from the anterior circumflex pierce the lesser. The *subscapularis* tendon occupies the inner face of the latter process, below which a fleshy slip of the muscle is inserted.

At the top of the bicipital groove is the **fovea capitis**, for the attachment of the gleno-humeral ligament, and a hole for the branch of the anterior circumflex artery which nourishes the head.

The shaft of the humerus is sinuously curved, the upper articular end projecting behind, the lower in front of, the axis of the shaft. The whole humerus has undergone a torsion in development through an angle of 30° . The deltoid tuberosity consists of three rough lines converging below, for the terminal tendons of the muscle (fig. 232).

The internal epicondyle is convex in front, grooved by a **sulcus ulnaris** for the ulnar nerve behind; its apex points backwards, and as the arm hangs by the side it is on a plane posterior to the outer epicondyle. From the ridge above it arises the *pronator teres*, from the front and inner part the *flexor carpi*

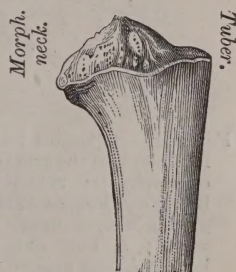


Fig. 231.—Section showing morphological neck of humerus.

radialis and *palmaris longus*, and to its lowest and innermost part the *flexor sublimis digitorum* and *flexor carpi ulnaris*. The capsule of the elbow is attached around its outer margin close to the base of the inner cone of the

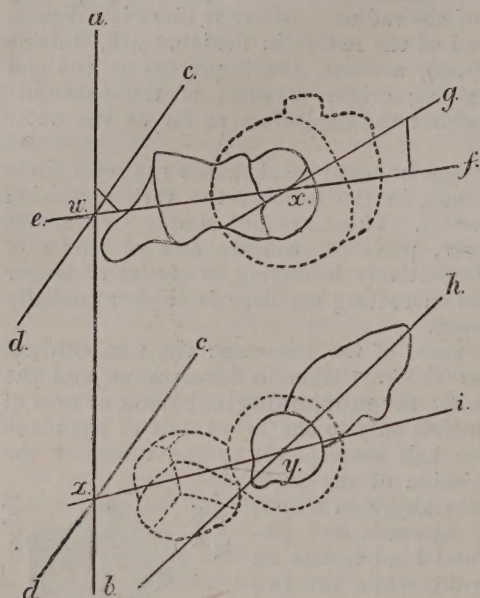


Fig. 232.—Superposed diagrams of the upper and lower ends of the arm bones, showing the amounts of epiphysary rotation—*a, b*, sagittal plane of body; *e, f*, longest axis of lower end of humerus; *g*, long axis of upper end, angle of intersection = 30° ; *h*, long axis of lower end of forearm bones; *i*, long axis of upper end. The angle at $w = 80^\circ$ represents the inclination of the axis of the lower end of the humerus to the sagittal plane when the hand is forcibly supinated, but in the ordinary position of rest the inclination to the sagittal plane is, $c.w.f = 80^\circ - 20^\circ = 60^\circ$; *c, d*, represents the sagittal plane in this position, and is nearly parallel to *h*.

that for the inner epicondyle at five; (7) for the trochlea at eleven; (8) for the outer epicondyle at thirteen years. The sixth of these joins the shaft at eighteen, the other three unite at sixteen into a lower epiphysis, and join the shaft at seventeen. At five months the humerus measures 45 mm., at birth 60 mm., at four years 125 mm. The adult male humerus is about 355 mm. long and the female 320 mm. Its proportion to the stature averages 20.7 per cent. in European males, 19.9 in females. The humerus articulates with three bones, gives origin to fifteen muscles, and insertion to nine.

Proper Ligaments.—In this category the transverse humeral ligament, which converts the bicipital groove into a canal, and the outer and inner intermuscular septa, and, when present, the supracondyloid ligament, may be included.

91. SHOULDER-JOINT.—This is the freest enarthrodial joint in the body, as the shallow glenoid cavity and the lax capsule allow the bony surfaces to move nearly in all directions. The bones are retained in contact by the surrounding muscles, which are the *deltoid*, *supraspinatus*, *infraspinatus*, *teres minor*, *long head of triceps*, *subscapularis*, *coraco-brachialis*, and the *short and long heads of biceps*.

trochlea. The outer epicondyle is short, convex behind, and its extremity inclines forwards. To its upper part is attached the *extensor carpi radialis brevis*, below which, in order from above downwards and backwards, arise the *extensor digitorum communis*, *extensor minimi digiti*, *extensor carpi ulnaris*, *anconeus*, and, close to the margin of the cartilage, *supinator brevis* and capsular ligament.

The inner edge of the trochlea forms an arc of 210° , of a circle 13 mm. radius, the narrowest part 320° , of a circle 9 mm., the outer edge 180° of 11.5 mm. This articular mass is only covered with cartilage for four-fifths of its surface, its upper surface in front and behind being covered by synovial membrane. The posterior breadth of the trochlea is 1.17 of its anterior. The axis of the trochlea is oblique, cutting that of the humerus at an angle, salient outwards, of 105° in the male, 108° in the female.

Development.—The humerus ossifies from eight points: (1) a perichondral centre for the shaft appears about the fifty-eighth day, and extends rapidly; (2) an entochondral centre for the head fifteen months after birth; (3) one for the great tuberosity in the third year; (4) one for the lesser at five—these unite to form the upper epiphysis at six, and join the shaft at twenty; (5) the centre for the capitulum appears at three; (6)

Beneath the deltoid, the front of the joint is invested by a variable connective expansion, the *semi-vagina humeralis* (fig. 224), continuous above with the front margin of the coraco-acromial ligament and overlying the *spinati* tendons, attached below partly to the capsule, partly to the fasciæ of the *infraspinatus*, *subscapularis* and arm.

On removing this expansion and the underlying tendons the **capsular ligament** is exposed, attached around the outer margin of the glenoid cavity, and to the anatomical neck of the humerus, close to the margin of the encrusting cartilage above, but descending to about 1 cm. below the morphological neck below. It bridges by transverse fibres the space between the spines of the tuberosities bordering the bicipital groove, and completes the canal for the long *biceps* tendon. The capsule is strengthened by the attachment thereto of the *spinati* tendons and some fibres from the long tendon of the *triceps*. It is pierced by the *biceps* tendon as it leaves the joint, and by the upper edge of the *subscapularis* tendon. At both deficiencies the synovial membrane is reflected on the respective tendons. To its upper surface a wide accessory **coraco-humeral ligament** is attached, passing from the inferior margin of the outer edge of the coracoid process, under the coraco-acromial ligament, to the greater tuberosity of the humerus internal to the *supraspinatus* tendon.

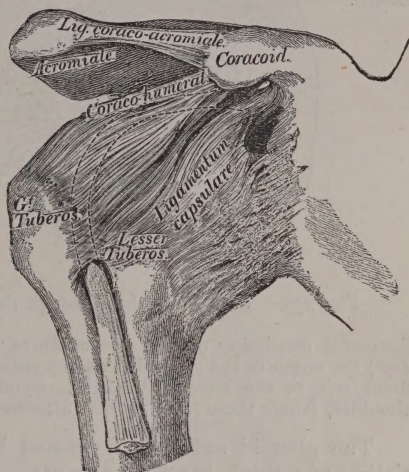


Fig. 233.—Shoulder-joint, front view, showing the subcapsular deficiency.

The capsule is thicker above and below than elsewhere, and consists of several planes of longitudinal fibres with intervening scattered circular fibres. Anteriorly two sets of acces-

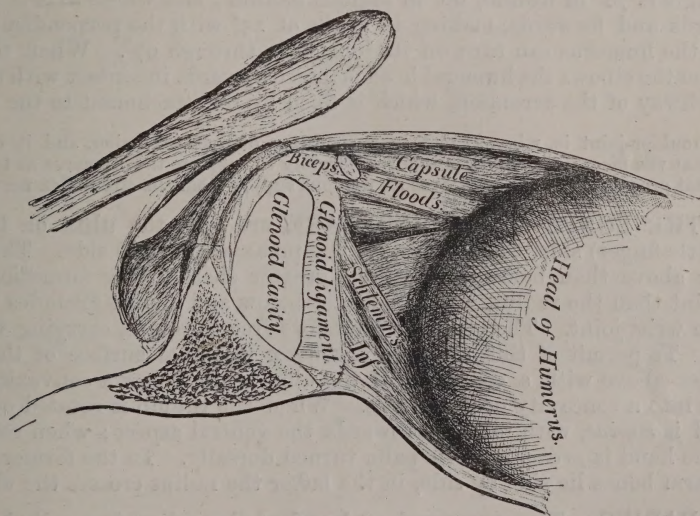


Fig. 234.—Shoulder-joint opened from behind and below, showing the three gleno-humeral folds.

sory longitudinal fibres strengthen it (*fræna suspensoria*), ascending respectively from

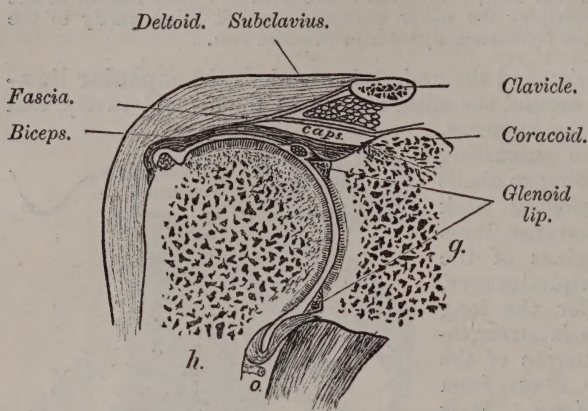


Fig. 235.—Vertical section through the shoulder.

ligament) consisting of two sets of fibres, one from above, the other from below (fig. 234, *Inf*) the notch in the glenoid margin; both sets being inserted into the humeral neck on the inner side of the lesser tuberosity. Synovial processes, which are few elsewhere in the shoulder, fringe these folds at their attached borders, and overlie the *biceps* tendon.

The glenoid cavity is deepened by the **glenoid lip** of fibro-cartilage, consisting of a thick band of concentric fibres, including a few cartilage cells; it is separated from the capsule by a furrow, from the articular cartilage by a line. By its flexibility it preserves the uniformity of the contact between the sometimes dissimilar curves of the glenoid cavity and humeral head. Above, the long tendon of the *biceps* and the superior gleno-humeral fold are attached to it.

The area of the glenoid cavity is $\frac{1}{4}$ that of the surface of the humeral head. The limb in circumduction travels on the surface of an elliptical conoid, whose apical angle is 70° in frontal, 90° in sagittal section; and whose axis is inclined downwards and forwards, making an angle of 25° with the perpendicular. In rotation the humerus can turn on its long axis through 97° . When the body leans upon the elbows the humeral head is forced upwards in contact with the overlying archway of the acromion, which is fixed by its attachment to the clavicle.

The shoulder-joint is, when at rest, in a condition of over-extension, and it is on this account that the *biceps* tendon is brought so forcibly to bear on the humerus as to produce the bicipital groove. The joint receives its nervous supply from the circumflex nerve.

92. THE BONES OF THE FOREARM are two, the **ulna** on the post-axial (little-finger) side, the **radius** on the preaxial (thumb) side. The former is larger above than below, and takes a greater share in the formation of the elbow-joint than the radius, which is larger below and almost excludes the ulna from the wrist-joint. The radius is therefore free to rotate, carrying the hand with it. To permit of this rotation, a convex marginal surface of the radius articulates above with a concavity of the ulna, while below a convexity of the ulna fits into a concavity of the radius. When the thumb is rotated outwards, the hand is *supine*, with its palm towards the ventral aspect; when rotated inwards the hand is *prone*, with its palm turned dorsally. In the former position the forearm bones lie side by side, in the latter the radius crosses the ulna.

93. RADIUS.—The upper end or **head** of the radius is a cylindroid disc with a shallow terminal concavity which receives and rotates on the capitulum humeri. It is clothed with cartilage on its upper face and around its edge, of

Gleno-humeral Folds.

—If the capsule be opened by a vertical incision behind and below, midway between the bones, the internal surface of its front wall appears irregular. A projecting **superior gleno-humeral fold** (Flood's ligament) lies above the *subscapular* tendon, along the anterior edge of that of the *biceps*, above which it arises from the glenoid ligament, passing to the **fovea capitis humeri**. This corresponds to the round ligament of the hip. Below the *subscapular* tendon is an **inferior gleno-humeral fold** (Schlemm's

which the internal part articulates with the lesser sigmoid cavity of the ulna, while the rest of the margin is surrounded by and rotates within the orbicular ligament. Beneath the head is the **neck**, which joins the **shaft** at the prominent **tubercle** on the inner side of the bone, into the dorsal border of which the *biceps* is inserted.

The *axis* of the radius is sigmoidally curved; that of the neck forms with that of the shaft an angle of 116° salient forwards and inwards. The line of the former, if prolonged, leaves the bone below the tubercle, and traversing the lower end of the ulna emerges between the ring and little fingers. The axis of the shaft is curved, its concavity being directed forwards and inwards.

Below the tubercle two **oblique lines** descend outwards, one *anterior*, the other *posterior*. Where these approximate below, at the middle third of the bone, there is a small oval **pronator impression** on the summit of the curve of the outer surface, for the insertion of the *pronator teres*. The space on the outer side of the bone between these lines is the **supinator surface**, into which the *supinator brevis* is inserted. From the anterior oblique line, the radial head of the *flexor sublimis digitorum* arises; the posterior forms the upper limit of the oblique surface for the origin of the *extensor ossis metacarpi pollicis*; below which, from the hinder margin

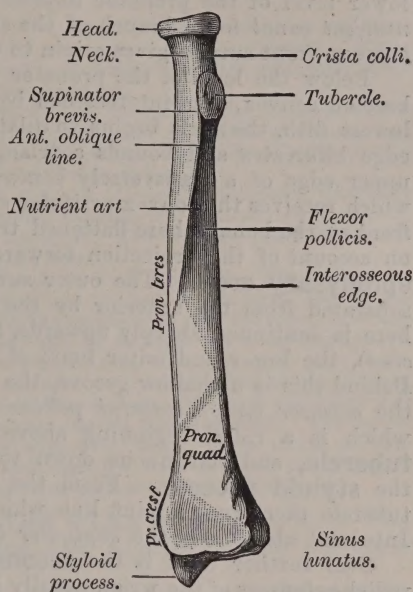


Fig. 236.—Right radius, front view— $\frac{1}{2}$.

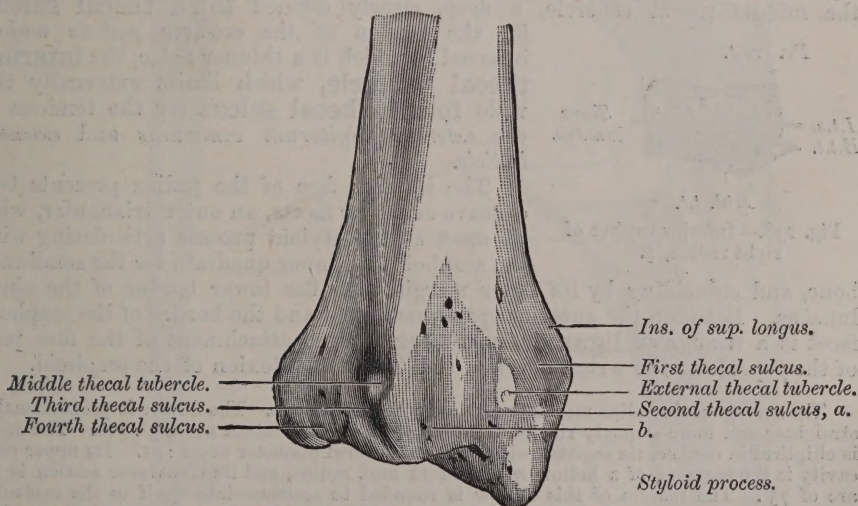


Fig. 237.

of the interosseous ridge for the middle fourth of the bone, is the origin of the *extensor pollicis minor*.

The inner aspect of the shaft is rounded for a short distance below the

tubercle, but a little above the upper point of trisection a sharp **interosseous edge** appears, which separates the anterior from the posterior surfaces. These surfaces, limited above by the oblique lines, are slightly concave as far as the lower level of the pronator impression. Near the anterior oblique line, the *nutrient canal* for a branch of the anterior interosseous artery ascends. The concave front surface gives origin to the *flexor pollicis longus*.

Below the level of the pronator impression the three surfaces of the bone become convex, the interosseous being the only sharp edge. At about its lowest fifth, the shaft begins to dilate towards its carpal end, the interosseous edge bifurcates and bounds a triangular *inner surface*, whose base is at the upper edge of a transversely concave and cartilage-covered **sinus lunatus**, which receives the convex articular surface at the lower end of the ulna. The front of the bone is here flattened transversely, but appears vertically concave on account of the projection forward of an irregular sharp lip, the **anterior epiphysary crest**. The outer surface also widens at the lower end, being separated from the anterior by the outer end of the epiphysary crest, which here is continued sharply upwards, forming a **pronator crest** (fig. 236, *Pr. crest*), the lower and outer limit of the insertion of the *pronator quadratus*. Behind this is a shallow groove, the **first thecal sulcus**, for the tendons of the *extensor ossis metacarpi pollicis* and *extensor pollicis minor*, posterior to which is a ridge beginning above in a projection, the **external thecal tubercle**, and continuous down to the lowest point on the bone which is the **styloid process**. From the outer end of the pronator crest to this tubercle there runs a faint line which limits anteriorly the first thecal sulcus. Into and above this the *supinator longus* is inserted.

Still further back is the **second thecal sulcus** for the long and short radial extensors of the wrist, usually divided into two by a faint ridge. Behind this is the **middle thecal tubercle**, a sharply defined knob separating the outer from the posterior surface.

The posterior surface for the lower fifth is convex, and presents, internal to the middle thecal tubercle, a deep, clearly defined **third thecal sulcus** for the tendon of the *extensor pollicis major*, internal to which is a thinner ridge, the **internal thecal tubercle**, which limits externally the wide **fourth thecal sulcus** for the tendons of the *extensor digitorum communis* and *extensor indicis*.

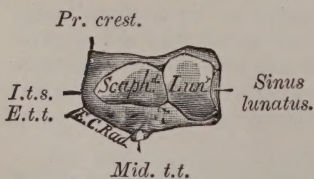


Fig. 238.—Inferior surface of right radius, $\frac{1}{2}$.

The inferior face of the radius presents two concave articular facets, an outer triangular, with its apex at the styloid process articulating with the scaphoid; an inner quadrate for the semilunar bone, and coinciding by its inner margin with the lower border of the sinus lunatus. Between the anterior epiphysary crest and the border of the scaphoid facet is a triangular **ligamentous area** for the attachment of the fore part of the capsule of the wrist, bevelled to allow of the flexion of the scaphoid.

The average male radius measures 250 mm.; the female 220. The former is proportionally straighter and more strongly ridged. Its length is to the stature as 14.3 : 100. The head is elliptical in outline, its sagittal being to its transverse diameter as 22 : 21. Its upper concavity is the segment of a hollow sphere of 12 mm. radius, and its transverse section is an arc of 75°. The margin of this hollow is rounded to accommodate itself to the caputular sulcus and outer margin of the trochlea humeri. The articular circumference of the head is deep on its inner side for 150° of its extent, with a sharp lower edge. For the remaining 210° the circumference is more slightly cartilage clad and irregularly rounded.

The neck is wider sagittally than transversely, as it presents a faintly marked blunt ridge (*crista colli*) ascending from the tubercle at right angles to the line of action of the *biceps*. The tubercle is about 20 mm. long by 12 broad, and is a little below, but turned towards,

the tubercle of the ulna. It is mainly a cancellous thickening of the bone covered with a thin compact crust, but behind it the compact tissue is thickened. In front it is smooth and covered with a bursa, below there is often a rough spot for the attachment of the oblique ligament; behind, the bone is smooth where the edge of the *supinator brevis* presses on it in extreme pronation.

The interosseous edge is blunt and thickened above, where it receives some strong fibres from the back of the ulna, which decussate with the main fibres of the membrane. Where the line bifurcates below, the membrane is attached to its hinder edge, the triangular space in front being occupied by fibres of *pronator quadratus* and fat.

The whole lower end of the radius is bent forwards, and the hinder edge descends a little lower than the front. The scaphoid facet forms transversely 50° of a circle of 20 mm., and sagittally 90° of one 10 mm. in radius. The semilunar facet forms sagittally 65° of a circle of 12 mm., and the sinus lunatus forms 45° of a circle of 26 mm. radius.

Structure.—The upper end of the radius consists of close orthogonal, internally rounded cancelli; the lower end of coarser orthogonal cancelli, the vertical rods, especially those arising from the anterior wall, being the strongest. The weakest plane is situated obliquely a short distance above the lower epiphysary line.

Development.—Ossification begins in the eighth week of foetal life. The nucleus for the lower epiphys appears above the scaphoid facet twenty months after birth, and by the tenth year has extended to the styloid process. By the seventeenth year the thecal tubercles are ossified as up-jutting spurs from the epiphys; and by nineteen the lower epiphys is synostosed to the shaft. In the upper epiphys, which forms only the upper part of the head, several small nuclei appear at the end of the fifth year, which unite at about seven years into one cake, and this consolidates with the shaft at sixteen. The neck and lower part of the head are ossified from the shaft. The radius articulates with four bones, gives origin to four muscles, and insertion to five. All the pronator and supinator muscles are inserted hereinto.

94. THE ULNA is a little longer than the radius and slightly curved, its upper

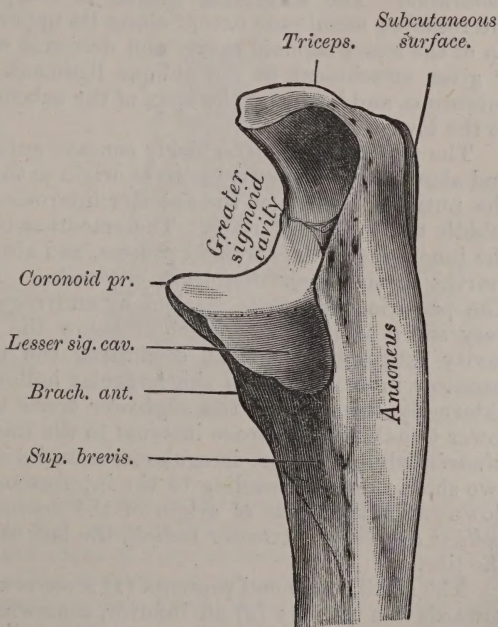
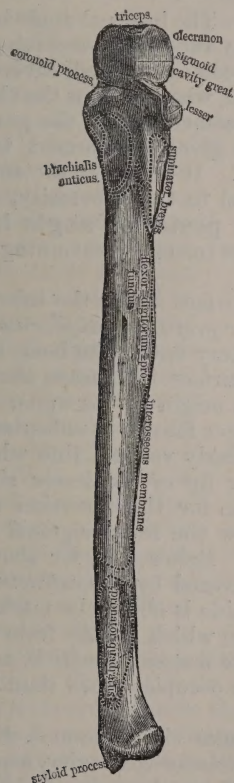


Fig. 239.—Front view of left ulna, $\frac{2}{3}$. Fig. 240.—Outer surface of upper end of left ulna, $\frac{1}{4}$.

end being directed forwards and inwards, its lower outwards and backwards. Its upper articular surface, the **greater sigmoid cavity**, is a deep

anterior hollow, not placed terminally, whose floor is raised into a vertical middle elevation, dividing it into two lateral parts to fit the two cones of the trochlea. Of these the inner is the larger and deeper. A rough transverse non-articular line, ending in a marginal notch at each end, crosses the cavity transversely and marks off the **olecranon process** above from the shaft below. The olecranon process presents an upper surface, with inflexed point, for the insertion of the *triceps*; a posterior triangular surface, which is flat, subcutaneous, and continued into the shaft, an internal tubercle for the origin of the *flexor carpi ulnaris*, and an outer sharp edge, below which the capsule of the elbow is inserted.

The lower lip of the sigmoid cavity is the **coronoid process** which projects forwards with a nearly horizontal upper surface, which, like that of the olecranon, is concave sagittally and convex transversely. Its anterior edge extends 7 mm. in front of the plane of the tip of the olecranon, and presents a sharp inflexed apical tubercle within the capsule of the elbow, and a rough, thick, inner tubercle, whose upper surface bears against the inner cone of the trochlea, and gives attachment below to the *pronator teres* and *flexor pollicis* muscles. Its outer edge is hollowed into a sagittally concave **lesser sigmoid cavity**, for articulation with the head of the radius. The inferior surface is oblique, and merges into the front of the shaft at the rough **tuberosity** of the ulna, into which the *brachialis anticus* is inserted.

The shaft presents three angles and three surfaces. The internal angle begins at the inner tubercle of the coronoid, and skirts the tuberosity, receiving the inner part of the *brachialis* tendon. Below this it becomes rounded, covered by the *flexor digitorum profundus* as far as its lower fourth, where it joins the oblique **pronator ridge** which limits the narrow strip of attachment of the *pronator quadratus*. The **external angle** is sharp, and gives attachment to the interosseous membrane except along its upper sixth. It begins at the anterior lip of the lesser sigmoid cavity and descends external to the tuberosity, where it gives attachment to the oblique ligament. The **posterior angle** is subcutaneous, and begins at the apex of the subcutaneous triangle, continuing down to the lower end.

The portion of the irregularly concave anterior surface below the tuberosity and above the pronator ridge gives origin to the *flexor profundus digitorum*; and the nutrient branch of the anterior interosseous artery enters the bone in the middle third of this surface. The smoother inner surface is concave above on the inner side of the coronoid process, and also gives origin by its upper three-fourths to the *flexor digitorum profundus*. Its lower fourth is subcutaneous. The posterior surface is marked by an irregular, nearly vertical line which is very sharp at its commencement below the hinder lip of the lesser sigmoid cavity (**supinator crest**), separating the triangle for the insertion of the *anconeus* internally, from the irregular hollow below the lesser sigmoid cavity externally, from which the *supinator brevis* arises. Below this, for about the lower two-thirds, the space internal to the line is covered by the *extensor carpi ulnaris*, while the more irregular area on its outer side is obliquely marked by two short ridges descending to the interosseous edge which isolate from above downwards, the areas of origin of the *extensor ossis metacarpi pollicis*, *extensor pollicis longus*, and *extensor indicis*, the last of which occupies more than half of the line.

The small lower end presents (1) a convex articular circumference, directed towards the radius; (2) an inferior, somewhat crescentic convexity, separated by synovial membrane from the triangular fibro-cartilage; (3) a deeply hollowed inner depression for the attachment of the triangular cartilage; (4) a cylindroid styloid process, whose posterior surface is continuous with the subcutaneous area and whose anterior surface also gives attachment to the cartilage, and which is grooved behind for the tendon of the *extensor carpi ulnaris*.

The curve of the lesser sigmoid cavity forms about 80° of a circle of 13 mm. radius, that of the greater forms 130° of 10 mm. The articulation at the lower end presents nearly 150° of a circle of 1 cm., and in females often appears sub-globular.

Development.—The shaft of the ulna begins to ossify in the eighth week; a second nucleus appears at the lower end about the fourth year, which joins the shaft at twenty; a third centre forms at the top of the olecranon at ten, which unites at seventeen. Most of the shaft, and very little of the epiphysis enters into the elbow-joint, which is peculiar as being essentially a shaft articulation. In the styloid process an accessory terminal centre is not uncommon, appearing at twelve and joining the rest of the epiphysis at sixteen.

The ulna articulates with two bones and one cartilage, gives insertion to three muscles, and origin to ten.

95. THE ELBOW-JOINT is structurally single, with one synovial cavity and suite of ligaments, but is functionally complex, and made up of three joints which differ in the kind and degree of their motions. The humero-ulnar joint is a screw ginglymus, allowing of flexion and extension only; the humero-radial is an enarthrosis wherein the socket travels on the ball and can be rotated as well as flexed; while the radio-ulnar is a trochoid wherein the radial head rotates, around its own vertical axis, upon the ulna. The joint is protected behind by the *triceps*, internally by the muscles arising from the inner epicondyle, in front by the *brachialis anticus* and *biceps*, and externally by the muscles attached to the outer epicondyle. Beneath these the joint is surrounded by a capsular ligament of unequal thickness; here and there strengthened peripherally by accessory ligaments, and internally by fat-holding synovial folds. This capsule is attached above to a line on the humerus, which arches over the coronoid and radial fossæ in front, and which crosses through the upper part

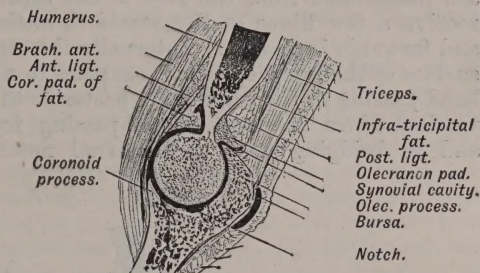


Fig. 241.—Sagittal section through humero-ulnar joint, $\frac{1}{2}$.

The humero-ulnar joint is a screw ginglymus, allowing of flexion and extension only; the humero-radial is an enarthrosis wherein the socket travels on the ball and can be rotated as well as flexed; while the radio-ulnar is a trochoid wherein the radial head rotates, around its own vertical axis, upon the ulna. The joint is protected behind by the *triceps*, internally by the muscles arising from the inner epicondyle, in front by the

brachialis anticus and *biceps*, and externally by the muscles attached to the outer epicondyle. Beneath these the joint is surrounded by a capsular ligament of unequal thickness; here and there strengthened peripherally by accessory ligaments, and internally by fat-holding synovial folds. This capsule is attached above to a line on the humerus, which arches over the coronoid and radial fossæ in front, and which crosses through the upper part

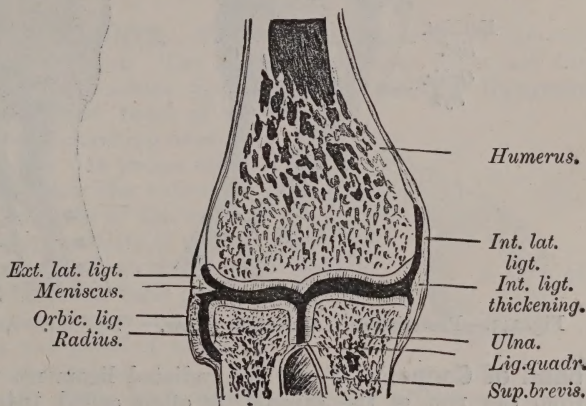


Fig. 242.—Coronal section through the right elbow.

of the olecranon fossa behind, and on each side skirts the lower surface of the epicondyles close to their cartilage-clad areas. Below, it is attached to the ulna immediately outside the lips and edges of the olecranon and coronoid processes, and around the inner edge of the greater sigmoid cavity. Externally it is only attached to the radius by weak areolar tissue, being for the most part inserted into the upper edge and outer surface of a circular funnel-shaped band, the **orbicular ligament** (fig. 244), which is attached to the front and hind lips of the lesser sigmoid cavity, and embraces the head and neck of the radius, around which it makes about three-quarters of a circle, its lower narrow border tightly engirdling the neck of the bone. The entire inner surface of the

orbicular ligament is continuously lined by synovial membrane, which facilitates rotation of the radius.

The front of the capsule is strengthened by oblique bands passing from the front of the inner epicondyle to the outer part of the coronoid process and orbicular ligament. These are sometimes called the **anterior ligament**, but are inseparable from the rest of the capsule. They limit over-extension, and receive a few fibres of the *brachialis anticus*, which draw the capsule upwards and forwards in flexion. Internally the strong accessory fibres from the lower surface of the inner epicondyle expand in a radiated manner, a strong anterior band passing to the coronoid, a posterior to the olecranon process, while a few vertical fibres intersect these, passing from olecranon to coronoid process; and so bridging over the internal notch of the sigmoid cavity (**oblique**

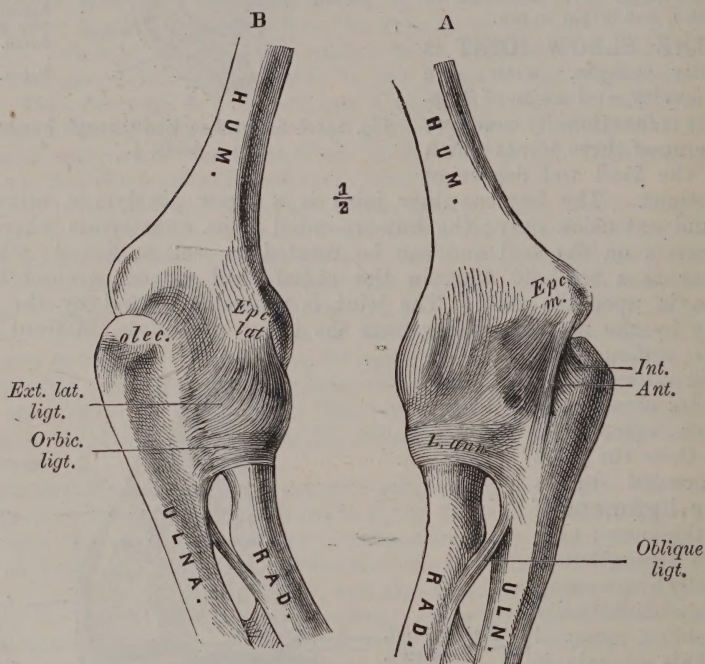


Fig. 243.—Posterior surface of right elbow. Fig. 244.—Anterior surface of right elbow.

band of Cooper). From this radiated ligament, which, though inseparable from the rest of the capsule, is often called **internal lateral**, the *flexor digitorum sublimis* arises. There are also strong, though indefinitely margined **external lateral** accessory fibres attached to the epicondyle above, and to the orbicular ligament and upper end of the supinator ridge on the ulna below; from this the *extensor digitorum communis* and *supinator brevis* arise. The posterior part of the capsule is very weak, and receives the insertion of a few deep fibres of the triceps, which draw it upwards in extension.

If the capsule be opened by detaching it from the coronoid and olecranon processes in front and behind, three large fat-holding lobes can be seen on its inner side. One of these lies above the olecranon, and is pressed by the *triceps* into the olecranon fossa in flexion; another lies above the coronoid process to fill the coronoid fossa in extension, and a third lies over the radial fossa. From the synovial side the internal lateral ligament appears coarsely fasciculated.

Posteriorly, a band of the capsule (**ligamentum cruciale**) passes from the angle between the back of the capitulum and the outer lip of the trochlea to the hinder lip of the lesser sigmoid cavity.

Within the joint are many synovial processes. Two masses of fat fill respectively the inner and outer notches on the floor of the greater sigmoid cavity, and an inflexed **meniscus lip** of synovial membrane and connective tissue projects from the upper edge of the orbicular ring between the upper margin of the radius and the capitulum.

The orbicular ligament, though consisting of very definite fibres, is yet inseparable from the rest of the capsule, and a weak lax portion of the capsule (**ligamentum quadratum**) occupies the interval between the lower lip of the lesser sigmoid cavity and the neck of the radius below the sharp-ridged portion of the head. This limits to some extent the range of pronation and supination. Three twigs from the ulnar, and two from the median nerve, supply this joint.

Extension in the elbow is limited by the tension of the soft parts in front when the axes of the arm and forearm become coincident (p. 44); flexion can take place through 140° , and is limited by the tension of the soft parts behind and the ligamentum cruciale, as well as by the bulging of the anterior soft parts. No lateral motion is permitted. Owing to the obliquity of the trochlea the axis of flexion is not at right angles to the median axis of the limb, hence when the elbow is extended and the hand supinated the axes of arm and forearm form an angle re-entrant outwards, more pronounced in the female than in the male. From the shapes of the articular surface the motion of the trochlea in the sigmoid cavity is that of a screw in a nut; the inclination of the screw averages 8° , and in the 140° of permitted motion the pitch amounts to 2.5 mm.; the ulna slipping radialwards in flexion. The right elbow is a right-handed screw, the left a left-handed.

96. RADIO-ULNAR LIGAMENTS.—The orbicular ligament is the only band of the upper radio-ulnar joint. The shafts of the two bones are tied together by the *oblique* and *interosseous ligaments*. The **oblique ligament** is a specialised and strengthened band of the fascia over the *supinator brevis* arching over the insertion of the *biceps* tendon. It passes downwards and outwards from below the tuberosity of the ulna to below the tubercle of the radius. The **interosseous ligament** consists of several planes of fibres which pass chiefly from the radius downwards to the ulna, the topmost band passing from the infratubercular area downwards to the outer edge of the ulna at the point of union of the interosseous and supinator ridges.

The two bones, originally close, have divaricated in the course of growth, and the interosseous space in the adult has become widest at the middle third. It is narrowed in pronation. Decussating ulno-radial bands cross the back of the membrane in the spaces between the extensors of the thumb, and derived from their sheaths.

The uppermost of these is much the strongest. The artery which lies in front of the sheath is often bridged over by superficial fibres, especially at its lower part. From the front surface of the interosseous membrane the *flexor digitorum profundus* arises, from the back the *extensor ossis metacarpi pollicis* and the *extensor pollicis minor*. The obliquity of the fibres usually increases from below upwards.

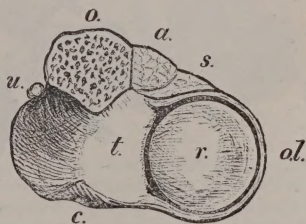


Fig. 245. — Horizontal section through left elbow, $\frac{2}{3}$ —a, anconeus; c, coronoid process; o, olecranon; o.l., orbicular ligament; r., head of radius; s., supinator brevis; t., trochlea surface of great sigmoid cavity; u, ulnar nerve.

The lower radio-ulnar joint is small, and separated from the wrist proper by the triangular cartilage. The head, formed by the ulnar capitulum, rotates in a socket formed by the radial sigmoid cavity and the cartilage below. The surfaces are not congruous, and the intervals are filled by synovial processes. The capsular ligament is loose, especially in front (*membrana sacciformis*), and continuous below into the border of the cartilage and the capsule of the wrist. The anterior interosseous nerve supplies this joint.

In pronation and supination the ulna is not quite at rest, but as the axis of motion traverses the shaft and lower end of this bone external to the styloid process, so this process can be felt to rotate a little in the opposite direction, the ulna receiving a lateral thrust when the long axis of the radial head is turned transversely, and being also affected by the traction of pronator quadratus and supinator brevis. The styloid process of the radius can ordinarily be carried through 165° , that of the ulna through 55° .

97. THE BONES OF THE HAND are arranged in three series—proximally there are eight *carpal* bones forming the wrist; medially there are five metacarpals forming the palm; distally there are fourteen *phalanges* forming the skeleton of the fingers—three in each finger, two in the thumb.

The **carpals** are short polygonal bones composed of round-meshed cancellous tissue included in a compact layer. Collectively they form an arch concave forwards, the scaphoid and trapezium externally, the pisiform and

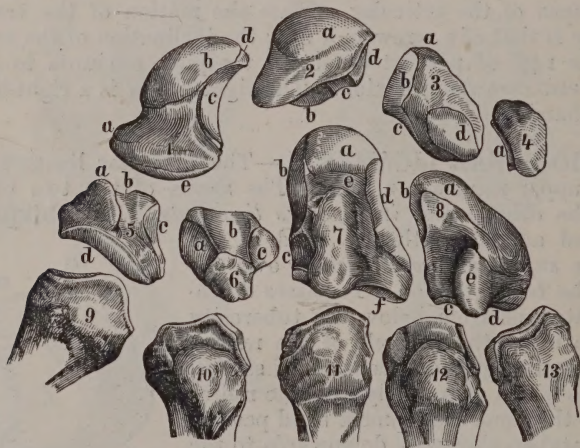


Fig. 246.—Front view of right carpal bones and the proximal extremities of the metacarpal bones, $\frac{3}{4}$.

unciform internally projecting as its lateral pier, which are united by the anterior annular ligament, and thus bound a canal which transmits the flexor tendons and the median nerve. The usually larger dorsal and the more irregular palmar surfaces of these bones are rough for the attachment of ligaments, while their lateral borders are articular and covered with cartilage.

The student will find it advantageous to provide himself with a separate as well as an articulated series, and to mark on each part of these the number indicating that part in the annexed description. To distinguish the side to which a bone belongs it should be placed as *in situ*, its surfaces being recognised. Discrimination of the right and left bones is only useful as a test of knowledge of the bones, and any system of *memoria technica* for the purpose apart from this is valueless. In the subjoined description the bones are taken from the radial to the ulnar side in each row.

Scaphoid (fig. 246, 1).—The largest bone in the first row presents—(1) a distal concave facet for the magnum (*c*); (2) an ulnar crescentic marginal facet for the semilunar (*d*); (3) a proximal oval convexity for the radius (*b*); (4) a dorsal triangular articular surface divided by a faint sagittal ridge into two facets, the radial for the trapezium (fig. 247, 5), the ulnar for the trapezoid (6); (5) a dorsal transverse ridge between 3 and 4 for ligaments (*l*); (6) a palmar radial tubercle palpable through the skin (fig. 247, *b*); (7) a rough linear border for interosseous ligaments between 2 and 3.

Semilunar (Os Intermedium).—This bone (fig. 246, 2) presents—(1) a distal articular concavity for the magnum (*b*); (2) a crescentic radial facet for the scaphoid; (3) a quadrate convex proximal facet for the radius (*a*); (4) a semicircular, ulnar surface for the cuneiform (*d*); (5) a distal bevelled articular margin for the unciform (*c*); (6) a *small* flat non-articular dorsal surface; (7) a *larger* rounded non-articular palmar surface, whose sides are cut so obliquely that its distal extremity is made to point radialwards towards the thumb. Facets 2 and 4 are separated respectively from 3 by rough edges above for ligaments. The bone is distinctly crescentic when seen from the side.

Cuneiform (Pyramidal or Os Ulnare)—fig. 246, 3) presents—(1) a basal semicircular radial surface for the semilunar (*b*); (2) a large triangular undulated articular surface directed distally and radially for the unciform (*c*); (3) a detached elliptical palmar facet for the pisiform (*d*); (4) a rough proximo-ulnar

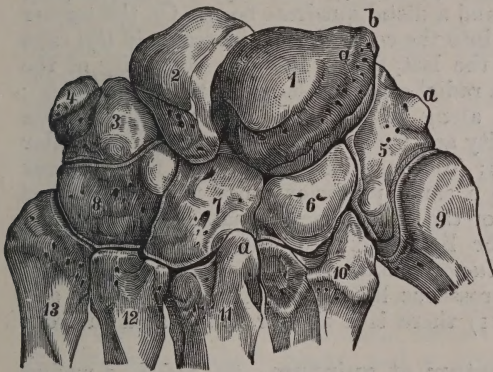


Fig. 247.—Back view of the bones of the right carpus and the proximal extremities of the metacarpal bones. The bones are numbered as in fig. 246.

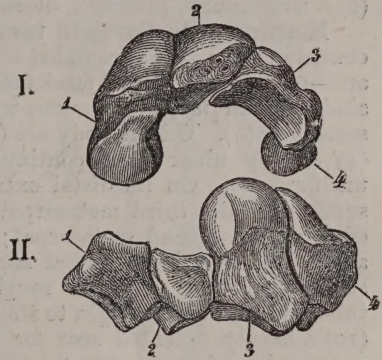


Fig. 248.—Back view of left carpus, the two rows separated from each other—I., first row—1, scaphoid; 2, semilunar; 3, cuneiform; 4, pisiform. II., second row—1, trapezium; 2, trapezoid; 3, magnum; 4, unciform.

surface whose proximal third is covered with fibro-cartilage (*a*) and synovial membrane to articulate with the triangular cartilage above; the ulnar portion is ridged distally, and gives attachment to ligaments (fig. 247). To none of these three bones are any muscles attached.

Pisiform (fig. 246, 4) is an elongated bony nodule whose axis points obliquely downwards and radialwards. It has (1) a dorsal articular facet for the cuneiform (*a*), which extends to its proximal, but not to its distal end; (2) a tuberosity distal end for the piso-unciform ligament; (3) a shallow groove for the ulnar artery on its radial side; (4) an inflexed and down directed apex pointing a little palmwards and distally, forming the end of a ridge from which the *abductor minimi digiti* arises distally, and into which the tendon of *flexor carpi ulnaris*

is inserted proximally. The appearance of flattening is due to the obliquity of the ridge between the two muscular attachments.

The bones of the second row are—

Trapezium (Os Carpale primum—fig. 246, 5); this presents—(1) a concave proximal facet for the scaphoid; (2) a quadrate radial facet for the trapezoid (fig. 246, c); (3) a large saddle-shaped distal surface for the first metacarpal (*d*); (4) a small angular facet on the projecting distal angle for the second metacarpal (fig. 247, between 9 and 10); (5) a deep palmar groove lined with cartilage for the *flexor carpi radialis* tendon (fig. 246, *b*); (6) a ridge overhanging this on its radial side for ligaments and giving origin to a slip of the *flexor brevis*, to the *opponens* and *abductor pollicis*, and to the ligament for the first metatarsal (*a*); (7) a concave rough radial side giving origin to the *opponens pollicis*; (8) a rough bituberculated dorsal surface, to the radial protuberance (fig. 247, *a*) on which the ligamentum radiale is attached, while the ulnar is for the trapezio-trapezoid ligament. This surface is ventrally directed in pronation (fig. 247, 5). The trapezium gives origin by its ridge to three muscles.

Trapezoid (Os Carpale secundum—fig. 246, 6), the smallest bone of this row, presents—(1) a large saddle-shaped distal articular surface for the second metacarpal; (2) a radial articular surface for trapezium (*a*); (3) an ulnar flat surface for the magnum (*c*); (4) a proximal surface for the scaphoid (*b*); (5) a small anterior surface which is rough for ligaments, and is prolonged as a characteristic triangular patch downwards and outwards between facets 1 and 2; (6) a large rough, roundish, dorsal surface for ligaments.

Magnum (Os Carpale tertium—fig. 246, 7), the largest of the carpals, consists of a proximal rounded head and a distal quadrate body. On the former are—(1) a convex radial facet fitting into the concavity of the scaphoid (*b*); (2) a similar ulnar facet continuous with the last, fitting into the concavity of the semilunar (*a*). On the body are (3) a radial quadrate facet for the trapezoid (*c*); (4) a long ulnar facet continuous along its whole hinder margin for the unciform (*d*). On its distal extremity are three facets—(5) a large triangular surface for the third metacarpal (*f*); (6) a marginal radial facet for the ulnar edge of the second metacarpal; (7) a small posterior ulnar facet, sometimes absent, for the dorsal radial angle of the fourth metacarpal. (8) The dorsal surface is wide, flat, and rough for ligaments; (9) the palmar surface is tuberos, and gives origin to the *adductor obliquus* and *flexor brevis pollicis* (*e*); (10) a deeply indented area for interosseous ligaments separates facets 1 and 3, extending from surface 8 to 9; (11) there is a similar rough area in front of 4.

Unciform (Ossa Carpalia quartum et quintum—fig. 246, 8), a wedge-shaped bone with its base towards the fingers, presenting (1) an ulnar undulated articular surface for the cuneiform (*a*); (2) an apical bevelled articular strip for the semilunar (*b*); (3) a long, flat, radial surface wide above, for the magnum; (4 and 5) two distal facets separated by a sagittal ridge for the fourth and fifth metacarpals (*c* and *d*); (6) a prominent hook-like palmar process, whose concavity looks radially, and which is rooted nearer to the distal than to the proximal end of the bone (*e*). To this unciform process the anterior annular ligament, the *opponens* and the *flexor minimi digiti* are attached; (7) a rough, flattish, bituberculated dorsal surface for ligaments.

The numbers of bones with which the carpal bones articulate are as follows:—Scaphoid 5, semilunar 5, cuneiform 3, pisiform 1, trapezium 4, trapezoid 4, magnum 7, unciform 5. Scaphoid, semilunar, cuneiform, and trapezoid give origin to no muscles; trapezium gives origin to 3, os magnum to 1, unciform to 2, pisiform to 2. Pisiform alone gives insertion to one muscle.

Morphology of the Carpal Bones.—The carpal bones form a threefold base of

support for the fingers, the scaphoid bears distally carpals I and II and metacarpals I and II, with their appended thumb and index finger. The intermedium bears carpal III, metacarpal III, and the middle finger. The ulnare bears the unciform and metacarpals IV and V, with the ring and little fingers. These three areas represent different portions of the hand, the outer portion is progressive, tending to increase in the specialisation of its parts; the second part is medial, the axis of motion; while the third part is retrogressive, its parts tending to coalescence and degeneration.

The carpals appear first as nine centres of chondrification in the mesoblast, these are radiale, intermedium, ulnare; below the radiale is the first carpal and the centrale; below the centrale is a second carpal, below the intermedium is a third carpal, and below the ulnare are carpalia four and five, which, however, are united even from the first. In the normal human embryonic carpus there is no trace of the second centrale. The ninth is the pisiform, probably the rudiment of a sixth digit, although from its condition it has come to simulate a sesamoid bone. The radiale and centrale unite and form the scaphoid, which, like the unciform, is thus a compound bone, though ossifying from a single centre. Ossification begins by a single centre in each bone, in the magnum at eight months after birth, in the unciform at one year, in the cuneiform at three, the semilunar and trapezium at five, the scaphoid at six, the trapezoid at eight, and the pisiform at twelve years of age.

98. THE METACARPALS are modified long bones, each presenting the following parts:—(1) An angularly cut proximal extremity, broader on its dorsal than on its palmar surface, with proximal articular facets for the carpals, and lateral facets for the neighbouring metacarpals, below which are rough spaces for ligaments; (2) a triquetrous shaft, slightly concave towards the palm, presenting on this aspect a sharp ridge separating two lateral sloping surfaces for *interossei* muscles. Dorsally, each exhibits a flat triangular area bounded by two lines which converge to a ridge above, but diverge distally and end on each side in a supra-articular dorsal tubercle; (3) a distal rounded head, somewhat quadrate in outline, flattened and marked by a pit for a ligament at each side, with its articular surface extending further on its palmar than on its dorsal aspect, projecting in front into two lateral cornua, which are separated by a flexor groove, and articulating with the proximal phalanx. The second is the longest; the third, fourth, fifth, and first being successively shorter. The first is the thickest and strongest, and ossifies from two centres, a shaft centre and a proximal epiphysis, while each of the others develop from a shaft centre and a distal epiphysis.

The first metacarpal diverges from its fellows and its palmar aspect looks ulnawards. It presents (1) a proximal saddle facet for the first carpal, with a prominent palmar beak for ligaments nearer its ulnar than its radial surface; (2) externally there is a proximal tubercle for the *extensor ossis metacarpi pollicis*; (3) its radial surface is wider and has a gentler slope than the ulnar, and receives the insertion of the *opponens pollicis*; (4) its dorsal surface is flat; (5) its carpal end has no lateral facets; (6) its head is flattish, with two very distinct palmar cornua for the two sesamoid bones; the outer cornu being the more prominent. Its nutrient artery descends on its ulnar side.

Its carpal end is convex transversely, the curve being 117° of a circle of 12 mm. radius, being thus a larger area of a smaller circle than the corresponding curve of the trapezium; sagittally it is concave, its curve being 90° of a circle of 16 mm., corresponding thus to the trapezium curve (fig. 80, p. 44).

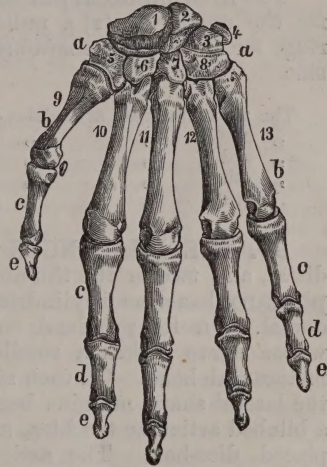


Fig. 249.—Skeleton of left hand; hinder view. Numbers as in fig. 246.

The **second metacarpal** presents (1) a wide base, centrally hollowed to sit on the ridge on the trapezoid; (2) a long, marginal, proximal ulnar facet for the third carpal; (3) a very small radial facet for the first carpal, behind which is (4) a tubercle for the insertion of the *extensor carpi radialis longior*; while (5) on its palmar side is a wider tubercle for the insertion of the *flexor carpi radialis*; (6) its outer distal cornu is longer than its inner; (7) below the facet for the third carpal is a bilobed lateral facet for the third metacarpal; (8) its nutrient canal ascends on its ulnar surface.

The **third metacarpal** (fig. 247, 11) presents (1) a styloid process (*a*) on the dorsal surface of the radial side of its base, into which the *extensor carpi radialis brevis* is inserted. This has occasionally an independent centre of ossification. (2) A terminal facet for the third carpal; (3) a bilobed facet for the second metacarpal on its radial side; (4) two oval facets, one dorsal and one palmar, on its ulnar side for the fourth metacarpal; (5) its palmar ridge is prominent for the *adductor transversus*; (6) its nutrient artery ascends on its radial side.

The **fourth metacarpal**, slender, with a square cut base, presents (1) a terminal facet for the unciform; (2) a posterior facet radially for the third carpal; (3) two radial facets for the third metacarpal; (4) a single ulnar facet for the fifth. Its nutrient artery ascends on its radial side.

The **fifth metacarpal** has no ulnar lateral facet, but (1) a terminal surface for the unciform; (2) a radial facet for the fourth metacarpal; (3) a palmar ridge for the *opponens minimi digiti*. Its nutrient artery ascends on its radial side.

The 1st metatarsal articulates with 4 bones, gives origin to 1 muscle, and insertion to 2.								
" 2nd	"	"	5	"	"	4	"	2.
" 3rd	"	"	4	"	"	4	"	1.
" 4th	"	"	5	"	"	3	"	0.
" 5th	"	"	3	"	"	2	"	2.

99. THE PHALANGES are three in each finger, proximal, medial, and distal, and two in the thumb, proximal and distal. Each **proximal** or **first phalanx** has a semi-cylindrical shaft, whose flat side is palmar, its convex side dorsal. On its proximal end is a single, transversely elongated concavity, whose curve makes a smaller arc of a larger circle than the corresponding metacarpal head. On each side of this in front are two tubercles, from which the lateral sharp margins begin and descend to the distal end, which exhibits a bilobed articular trochlea, medially depressed like a section of a transversely placed dice-box. The articular surface is wider and is more proximally extended on its palmar side than on its dorsal.

Each of these bones develops from two centres, one chief centre for the shaft, which appears in the ninth week, and a secondary proximal centre appearing in the third year, consolidating at twenty. The nutrient artery ascends in each. The proximal phalanx of the third finger is the longest, then that of the fourth, then the second, then the fifth, and lastly the first. That of the thumb is the broadest, with a flat, proximal articular surface, having a large dorsal, radial tubercle for the *extensor pollicis minor*, and a large palmar ulnar tubercle. That of the index has a larger radial than ulnar basal tubercle; they are less disproportionate in the middle finger, sub-equal in the ring, and in the little the ulnar exceeds the radial. The trochlear joint surface is also unequally lobed in each finger, and thereby each bone may be recognised.

The **medial** or **second phalanges**, also semi-cylindrical, have each a double concavity at the proximal end, with a median dorsal projection for the insertion of the *extensor* tendon, supplemented by tendons of the *interossei* and *lumbricales*; the lateral ridges are rough for the *flexor sublimis digitorum*

tendon. The distal end is trochlear, but smaller than that of the first phalanx. The medial phalanges of the middle and ring fingers are nearly equal in length; that of the second is stouter, but shorter, and the fifth is the smallest. Their shafts ossify in the tenth week, and a proximal epiphysis, often absent in the little finger, appears at four years, and consolidates about twenty.

Each **ungual** or **third phalanx** presents (1) a transverse proximal concavity of two hollows to fit the trochlea of the second phalanx; (2) a proximal transverse tubercle on its palmar surface for the tendon of the *flexor profundus digitorum*; (3) a horse-shoe shaped terminal **ungual process**, convex dorsally to bear the nail and its matrix, rough on its palmar side to be fastened by diverging fibres to the pulp of the finger. That of the thumb is the largest and widest, then, in order, those of the middle, ring, index, and little fingers. Ossification begins distally in the tenth week, and spreads proximally; a proximal epiphysis usually appears at five, and consolidates at nineteen.

Each proximal and medial phalanx articulates with two bones; into each proximal phalanx are inserted parts of two muscles; into each medial phalanx four muscles are inserted; into each ungual phalanx two tendons are inserted, and each only articulates with one bone. No muscle arises from any phalanx.

At the base of the first joint of the thumb are two sesamoid bones, the outer longer and narrower, the inner broader and shorter. They have each a facet to articulate with the cornua of the distal metacarpal surface, and a distal tuberosity for ligaments. They appear as centres of chondrification at two years of age, and begin to ossify at eleven.

100. THE WRIST-JOINT, unlike the elbow, is functionally simple, though structurally complex. The movements of the hand on the forearm are flexion and extension through 75° and 40° respectively; adduction through 55°, and abduction through 25°. These motions are distributed through three sets of joints, the radio-carpal, intercarpal, and carpo-metacarpal, which are closely related and move simultaneously. In the radio-carpal, rotation can take place through 12°; in the second, through 10°; in the third no rotation is permitted, except in that of the thumb, and that but slight. Motion in the wrist is really along a spiral line, with a translation of 20 mm. on a spindle of 30 mm. radius.

The wrist is separated from the lower radio-ulnar joint by the **triangular cartilage**, which is attached by an apex about 3 mm. thick to the styloid process of the ulna, expanding thence to a thin base which is attached to the margin of the sinus lunatus radii, where the fibro-cartilage blends with and infects the hyaline cartilage for some little distance. Its lower surface makes thus a continuation inwards of the lower surface of the radius. At the ulna the apex divides into two, one part is attached to the groove at the base of the styloid process, the other to the front of the process; between these two is a small mass of vascular areolar tissue, **ligamentum subcruentum**. Over this cartilage the ulna moves as one joint of a fan moves on another; the axis of rotation being the ulnar attachment of the cartilage.

The wrist is protected by strong tendons, internally those of the *extensor* and *flexor carpi ulnaris*; anteriorly the *flexor digitorum profundus*, *flexor digitorum sublimis*, *palmaris longus*, *flexor carpi radialis*. Externally the *extensor ossis metacarpi pollicis* and *extensor pollicis minor*, the *extensor carpi radialis longior* and *brevior*, and the *extensor pollicis major*; posteriorly the *extensor digitorum communis*, *extensor indicis*, and *extensor minimi digiti*.

Beneath these the bones are tied together by the **capsular ligament**, composed of many fascicles varying in strength and direction, which, although often unnecessarily divided, are not separable into distinct ligaments. These proceed for the most part from the radius and edges of the triangular cartilage to the first row of the carpals. A strengthened band (fig. 250, 4) passes obliquely downwards and inwards in front, from the radius to the semilunar and magnum (*ligamentum arcuatum*), another from the styloid process of the

radius to the tubercle of the scaphoid (*external lateral*, 7), a third series of fibres dorsally pass obliquely from the radius to the semilunar and cuneiform (*ligamentum rectum*—fig. 251, 2); a fourth extends from the tip of the styloid process of the ulna to the cuneiform constitutes the *internal lateral ligament*.

On opening the joint by cutting through the capsule dorsally three bands of the capsule are seen to project into the cavity of the joint, one from the radial styloid to the os magnum, and two, an inner and outer, from the radius to the semilunar. The synovial membrane appears much folded and fringed, especially on its posterior wall.

The bones of the first row of the carpus are united together by marginal *scapho-semilunar* and *semiluno-cuneiform* interosseous ligaments, which surround

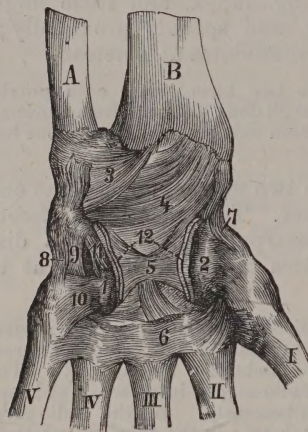


Fig. 250.—Ligaments in front of the wrist-joint—A, ulna; B, radius; 1 and 2, anterior annular ligament cut through at 12; 3, radio-cuneiform fibres of capsule; 4, intermetacarpal ligament; 5, unciform-metacarpal ligament; 6, trapezio-trapezoid ligament.

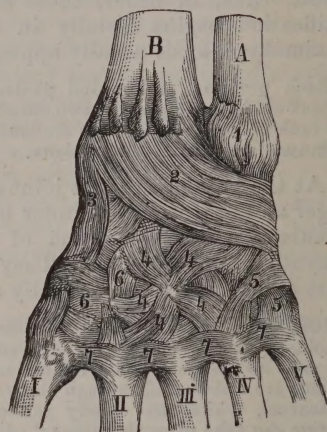


Fig. 251.—Ligaments of the back of the wrist—3, posterior surface of external lateral ligament; 4, slips of posterior intercarpal ligament radiating from the back of the magnum; 5, cuneiform-metacarpal slip; 6, trapezio-trapezoid ligament.

their contiguous facets proximally, and so enable the bones to present a continuous surface towards the wrist (fig. 252, c), while their intervening cavities are open distally to the intercarpal joint.

The wrist surface represents 110° of a circle whose radius is 29 mm., while the cavity formed by the radius and cartilage = 69° of a circle of 42 mm. radius.

The pisiform has a synovial cavity and capsule of its own, tying it to the cuneiform. It gives attachment also to a strong *piso-unciform* ligament (fig. 250, 11) fixing its lower end to the proximal edge of the hook of the unciform. On a deeper level and external is a slender *piso-carpal* ligament, attached distally to the third carpal, while internally is a stronger *piso-metacarpal* ligament passing to the fifth metacarpal (8, 9).

The ligaments of the intercarpal joint are—1. **Dorsal**, consisting mostly of transverse fibres which pass from the cuneiform, unciform, and the head of the fifth metacarpal to the dorsal ridges on the scaphoid, trapezium, and trapezoid, as well as by festooned slips to the metacarpals I and II, and to the back of the magnum. This ligament is thin and variable, covering a loosely-folded synovial membrane.

2. **Palmar intercarpal** consists of fibres radiating from the tuberosity of

the magnum to all the surrounding bones, hence it is sometimes called *ligamentum radiatum* (fig. 250, 5). They are attached to the scaphoid, semilunar, and cuneiform above, to the unciform, metacarpals II, III, IV, and V, trapezium, and trapezoid below. 3. Between these bones are five interosseous ligaments, a strong palmar between the unciform and magnum (fig. 252, *u*), and a weaker dorsal; a palmar and dorsal between the magnum and trapezoid, and a dorsal between the trapezium and trapezoid.

The **synovial cavities** in contact with the carpal bones are five: 1st, that in the radio-carpal joint (fig. 252, 2); 2nd, the piso-cuneiform; 3rd, the trapezio-metacarpal; 4th, a common intercarpal cavity extending between the first and second row, sending two proximal pouches between the bones of the first row, and one large prolongation downwards between the magnum and trapezoid which expands distally between the carpals and outer metacarpals (3); 5th, the fourth and fifth metacarpals have usually a separate synovial cavity between their bases and the unciform (5). The synovial cavity of the inferior radio-ulnar joint (1) communicates with the radio-carpal cavity in about three per cent. of hands.

The **carpo-metacarpal ligaments** are palmar, dorsal, and interosseous. The **palmar** ligaments are seven: one from the trapezium to the first metacarpal; one from the trapezium to the second metacarpal; three for the third metacarpal—one from the trapezium, one from the magnum, and one from the unciform; two others arising from the unciform go respectively to the fourth and fifth metacarpals. The *interosseous ligaments* join the opposed surfaces of the magnum and unciform above to the contiguous surfaces of the third and fourth metacarpals below. The nine *dorsal ligaments* are the strongest. Three pass to the second metacarpal, arising respectively from the trapezium, trapezoid, and magnum. Three pass to the third metacarpal: one from the trapezoid and two from the magnum. Two pass to the fourth metacarpal from the magnum and unciform respectively, and one to the fifth, which is continuous with the anterior as a partial capsule.

The **carpo-metacarpal joint of the thumb** is protected by a capsular ligament stronger behind than in front.

The **proximal ends of the metacarpals** are in contact, and the intercarpal synovial membranes send up small pouches between them. They are

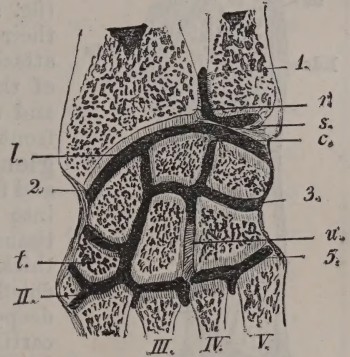


Fig. 252.—Synovial membranes of wrist-joint. In the specimen from which this was taken the semiluno-cuneiform ligament was deficient, so cavities 2 and 3 are represented as communicating.

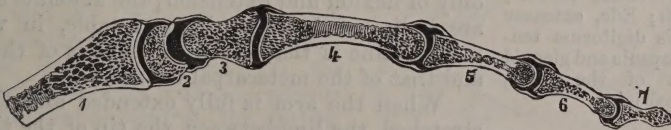


Fig. 253.—Section through the middle of the third finger, $\frac{2}{3}$ —1, radius; 2, semilunar; 3, magnum; 4, third metacarpal; 5, 6, 7, the phalanges.

united together by *dorsal* (fig. 251, 7), *palmar* (fig. 250, 6), and *interosseous* transverse fibres attached to each bone immediately below the articular surfaces.

At the distal ends of the metacarpals the fascia covering the anterior faces of the *interossei* muscles becomes strengthened at its lower border, receiving deep fibres from the palmar fascia, and it appears as a series of **anterior transverse ligaments** uniting the fronts of the capsules of the second, third, fourth, and fifth metacarpo-phalangeal joints (fig. 255). Beneath these transverse ligaments pass the *interossei* tendons, over them pass the *lumbricales*, and the vessels and nerves of the fingers.

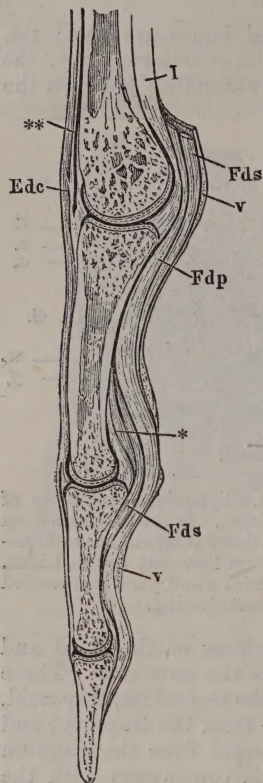


Fig. 254. — Ligaments of finger. Vertical section through second finger when extended showing ligaments, $\frac{3}{4}$ —Fds, flexor sublimis tendon; Fdp, flexor profundus tendon; v, sheath; Ede, extensor communis digitorum tendon; *, capsule and glenoid ligament of the interphalangeal joint.

The **metacarpo-phalangeal joints** are enarthrodial joints surrounded by capsular ligaments, which are weak behind under the extensor tendons (fig. 254, Ede), and very strong at each side where their fibres are specialised into lateral ligaments attached to the tubercles and hollows on each side of the metacarpal heads, and to the lateral ridges and anterior tubercles of the phalanges. From the front lip of the socket of the phalanx a meniscoid **glenoid ligament** (fig. 254) is continued upwards and forwards over the head of the metacarpal, merging into the weak capsule above, and attached by areolar tissue to the metacarpal bone. This ligament is thick at its phalangeal attachment, and composed chiefly of transversely directed fibres. It serves to deepen the socket, and is thickened into a fibro-cartilage at the line of attachment on each side where it plays over the cornua of the metacarpal facets, on each side of which it is attached to the lateral ligaments. Always in the thumb and sometimes on the other fingers, especially on the inside of the little finger, the fibro-cartilage ossifies into a sesamoid bone, receiving the insertion of short muscles.

The **second and third interphalangeal joints** are ginglymi, with capsular ligaments strengthened laterally into lateral ligaments which project into the cavities of the joints, and between which in front is an **anterior glenoid ligament** (fig. 254,*) similar to that in the metacarpo-phalangeal joint. The sheaths of the tendons are closely attached thereto, and with their radiating fibres are described in connection with the tendons.

The metacarpo-phalangeal joints are enarthrodial and permit of extension, flexion, ab- and adduction, and slight rotation. The interphalangeal joints allow only of flexion and extension; the amounts of motions are indicated in the subjoined table, in which the neutral line is that in which the axis of the phalanx and that of the metacarpal coincide.

When the arm is fully extended and the fingers stretched, the line between the tip of the thumb and index finger subtends at the eye an angle of 15° , the line joining the tip of the thumb and little finger subtends an angle of 18° . The average male index finger, bent at right angles at the metacarpo-phalangeal joint, measures from the flexure to tip approximately 4 inches or 10 centimetres. The student should determine these constants in himself, as they often prove useful, especially when travelling.

	Flexion.	Extension.	Abduction.	Adduction.
Met.-phal. index,	90°	28°	20°	40°
„ middle,	110°	22°	16°	38°
„ ring,	100°	15°	14°	22°
„ little,	115°	11°	25°	34°
„ thumb,	68°	0	12°	10°
1st interphal. index,	120°	0	0	0
„ middle,	112°	0	0	0
„ ring,	125°	0	0	0
„ little,	115°	0	0	0
„ thumb,	90°	30-80°	0	0
2nd interphal. index,	80°	0	0	0
„ middle,	80°	0	0	0
„ ring,	65°	0	0	0
„ little,	85°	0	0	0

101. THE PELVIC GIRDLE consists in the adult of a single bone (**os innominatum** or **hip-bone**) on each side, which abuts dorsally on the costal elements of the sacrum, and unites ventrally with its fellow. For terrestrial locomotion the girdle requires to be fixed to the vertebral column; while to suit the upright position, its upper part must be expanded to give attachment to muscles and to support the viscera. In addition to these requirements, the large size of the infant's head renders a wide diameter necessary for the cavity which it has to traverse in the female. These are the main factors which contribute to mould the human pelvis (fig. 237, 9).

102. THE HIP-BONE is irregular, curved somewhat like a screw-propeller, narrowed medially, wide at either end. It consists in the child of three elements—a dorsal, the **ilium**, which is the largest, and articulates with the sacrum behind; an anterior ventral, the **pubis**, which joins its fellow medially by synchondrosis; and a posterior ventral, the **ischium**. There is a rudimental fourth or **acetabular element**, but it fuses with the others at an early age. These elements unite in the **acetabulum** or socket of the hip, and ankylose together

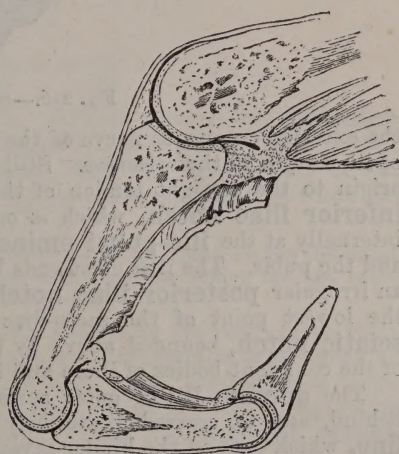


Fig. 255.—Vertical section through finger when flexed. Note the alteration in disposition of the synovial membrane and of the meniscus-like folds.

in the adult. The pubis and ischium diverge from each other in front of the socket to re-unite again, and thus form the boundaries of the large oval **obturator foramen**.

The **ilium** consists of a **body**, forming less than two-thirds of the acetabulum, and a widely expanded **ala** ending above in a $\sqrt{\text{ }}$ -shaped, irregularly thickened, subcutaneous **crest**, marked along its surface by three faint lines—outer, middle, and inner—which give attachment to the three flat muscles of the abdomen. The crest ends in front in a **superior spine** to which Poupart's ligament is attached. Below this is the **superior iliac notch**, transmitting

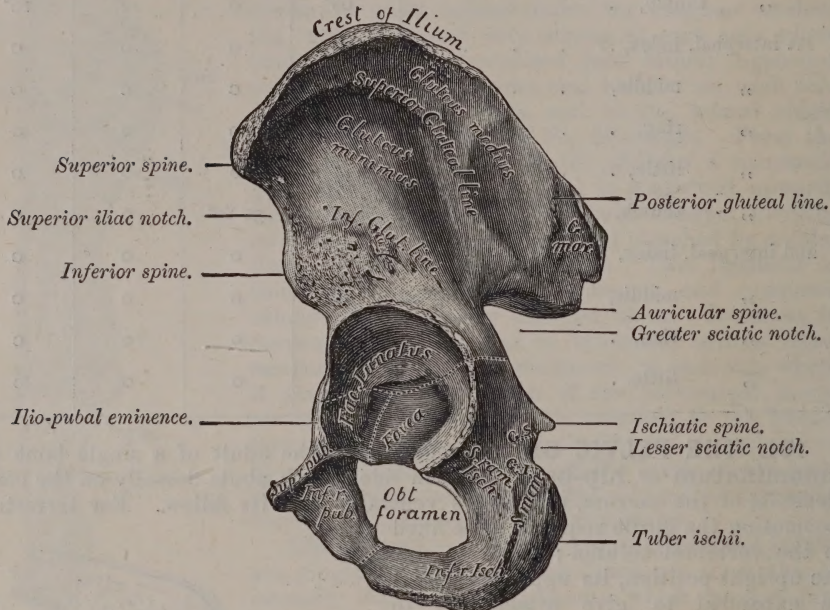


Fig. 256.—Hip-bone, outer side.

the external cutaneous nerve of the thigh, and giving origin by the upper half of its margin to the *sartorius*. Still lower is the rough **inferior spine** giving origin to the straight tendon of the *rectus femoris*, and bounding above the **inferior iliac notch**, which is occupied by the *iliacus*. This notch ends internally at the **ilio-pubal eminence**, which marks the union of the ilium and the pubis. The iliac crest ends behind in a **posterior spine**, separated by an irregular **posterior iliac notch** from an **auricular spine**, which marks the lowest point of the sacro-iliac joint. Below this is the deep **greater sciatic notch**, bounded above by the ilium and in front by the hinder edge of the confluent bodies of ilium and ischium.

The **dorsum ilii** or outer surface of the ala is convex in front, concave behind, and is crossed posteriorly by a nearly vertical **posterior gluteal line**, which cuts off the hinder seventh of the ala as a posterior gluteal surface from which the *gluteus maximus* arises. A longer curved **superior gluteal line**, commencing in front of this and ending at the superior spine, forms the lower boundary of a middle gluteal area, from which the *gluteus medius* arises. An indistinct, curved, **inferior gluteal line**, from the front of the sciatic notch to a little above the inferior spine, forms a lower limit to the inferior gluteal area for the origin of *gluteus minimus*. The dorsal surface ends below

at the edge of the acetabulum, immediately above which it is rough for the origin of the capsular ligament, and depressed into a pit behind the inferior spine for the curved head of the *rectus femoris*.

The inner surface of the ilium presents four areas, an anterior or **iliac fossa**, smooth and concave for the *iliacus*, bounded below by the **ilio-pubic line**, under which is the **pelvic surface** of the body of the ilium, making

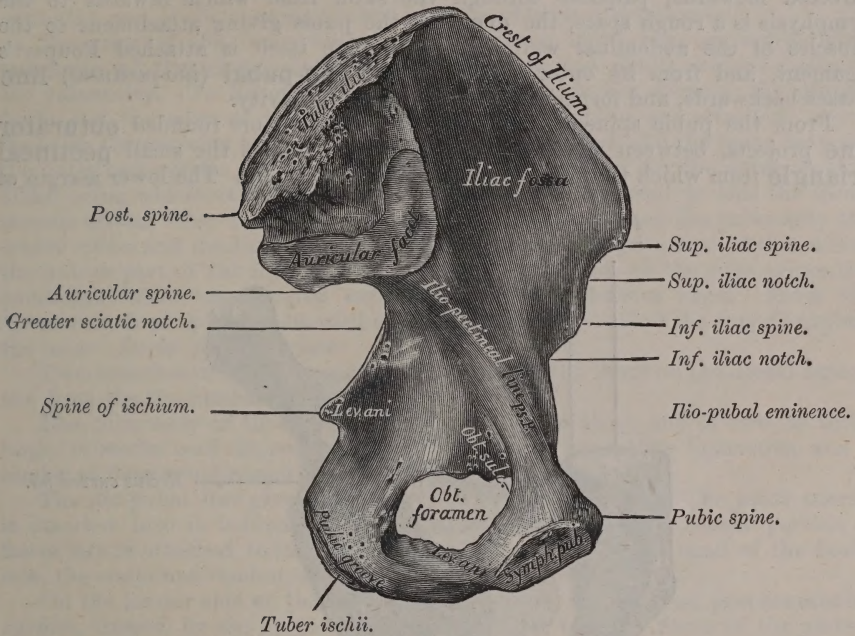


Fig. 257.—Hip-bone, inner side, $\frac{2}{3}$.

a small part of the wall of the true pelvis. Behind this is the **auricular facet**, an irregular surface joined by cartilage to the sacrum. Still farther back is the **tuberosity of the ilium**, into which the hinder part of the crest merges, marked by rough depressions for the sacro-iliac ligaments and for the origin of the *erector spine*.

The iliac area of the acetabulum may be marked by drawing a line from the ilio-pubic eminence to a point a little above the centre of the cavity, and continuing the line backwards from thence to the middle of the front edge of the sciatic notch.

The **ischium**, the second largest element, makes, by its body, more than two-fifths of the acetabulum, below which it descends backwards as an irregular short **superior ramus**, on whose hinder and outer surface is a large rough area, the **tuberosity** of the ischium, from which the hamstring flexor muscles of the knee arise. From the front of this the **inferior ramus** passes forwards, inwards, and a little upwards to become continuous about the middle of the inner boundary of the obturator foramen, with the inferior ramus of the pubis forming with it a continuous **ischio-pubic ramus**. From behind the junction of the body and superior ramus, the sharp **spine** of the ischium projects inwards, separating the **greater sciatic notch** above, from the cartilage-clad **lesser sciatic notch**, which intervenes between the spine and tuberosity of the ischium.

The **pubis** consists of a **body** which forms a little less than one-fifth of the acetabulum, a **superior ramus** extending thence downwards towards the middle line where its inner surface is united to its fellow, at the **symphysis**. Here it turns sharply downwards and backwards, forming an **inferior ramus**; the lower end of which joins the inferior ramus of the ischium. Near the ventral end of the superior ramus is a prominent **spine**, directed forwards, palpable through the skin, from which inwards to the symphysis is a rough space, the **crest** of the pubis giving attachment to the muscles of the abdominal wall. To the spine itself is attached Poupart's ligament, and from its outer side the sharp **ilio-pubal (ilio-pectineal) line** passes backwards, and forms the brim of the pelvic cavity.

From the pubic spine to the acetabular edge a more rounded **obturator line** projects, between which and the ilio-pubal line is the small **pectineal triangle** from which the *pectineus* muscle takes its origin. The lower margin of

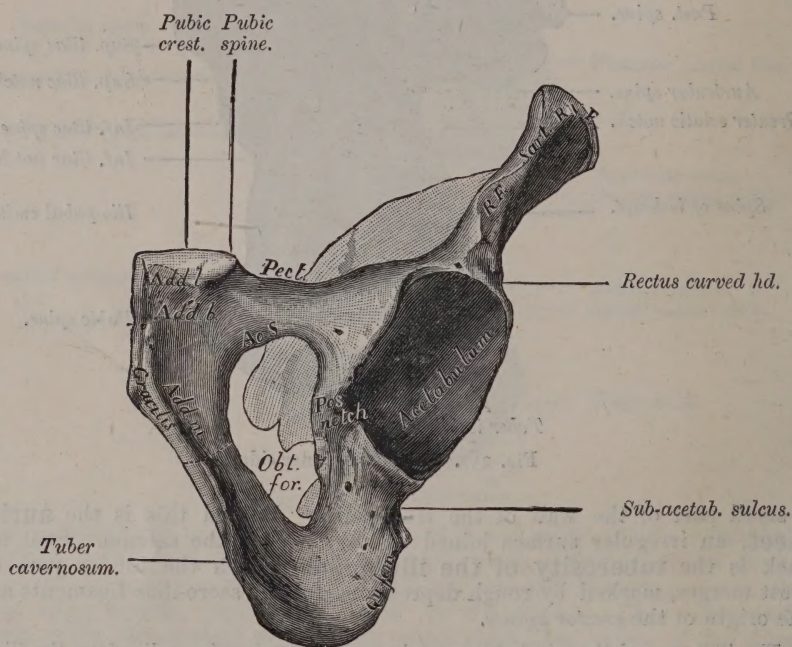


Fig. 258.—Anterior surface of pubis and ischium, $\frac{1}{4}$.

the ischio-pubal ramus is rough and everted especially in males, the **tuber cavernosum** for the attachment of the crus penis. On the median surface of the upper half of the superior ramus is the cartilage-covered area of the symphysis. Anteriorly the bone below the crest is rough, and gives attachment to the adductors of the thigh. Posteriorly it is smooth and in contact with the fascial envelopes of the bladder.

The **acetabulum** is a nearly hemispherical cavity looking outwards, forwards, and downwards, on the area of confluence of the bodies of the three elements. Its edge is sharp, slightly notched on the iliac side of the ilio-pubal eminence (iliac notch of the acetabulum), deeply on the ischiatic side of the union of ischium and pubis (the cotyloid notch). The surface of the cavity presents—(1) a crescentic, cartilage-clad **facies lunata** above, concave downwards,

ending in two cornua which border the cotyloid notch; and (2) a deep rough **fovea acetabuli**, mostly on the ischium, communicating with the notch and in the recent state filled with fat.

The **obturator foramen** is an irregular oval hole, triangular in the female, bounded by the body and superior pubic ramus above, by the ischium behind, and by the ischio-pubal ramus below. Beneath the superior ramus of pubis is an oblique channel for the exit of the obturator vessels and nerve, while the rest of the opening is closed by the obturator membrane.

The crest of the ilium widens at its anterior third into an overhanging **tubercle of the crest**, behind this it narrows and finally widens again at the tuberosity. To its outer margin below, towards the dorsum, the gluteal fascia and the edge of the *gluteus maximus* and *medius* are attached; above these for the anterior half the *external oblique* is inserted. To the space between the outer and middle lips the *internal oblique* is attached for the anterior two-fifths, being widest at the tubercle. From the line internal to this the *transversalis* arises. For the hinder third of this margin above the tuberosity the *erector spine* and lumbar fascia are attached; for the fifth in front of this, above the hinder part of the iliac fossa and on the ventral side of the edge arises the *quadratus lumborum*, covered externally by the *latissimus dorsi*. From the anterior inch of the outer lip of the crest immediately behind the superior spine, the *tensor fasciæ femoris* arises.

Two branches of the deep gluteal artery pierce the ilium on the dorsal aspect, one from the ilio-lumbar pierces it on the ventral.

The tuberosity of the ilium is divisible into two areas, one of two or three large tubercles and depressions for the posterior sacro-iliac ligaments, and a hinder of finer roughnesses for the *erector spine*.

The ilio-pubal line gives attachment to the pelvic fascia. The *psaos parvus* is inserted into it behind the ilio-pubal eminence. The pectineal portion of fascia lata is attached to its pubic part, together with Hey's band of the fascia lata, the conjoined tendon, and Gimbernat's ligament (p. 170).

On the hinder side of the body of the ischium is a convex post-acetabular surface, crossed by the *pyriformis*, and giving rise to a few fibres of the *gluteus minimus*. Below the acetabulum is a deep, rough, sub-acetabular groove pierced by branches of the sciatic artery. On its pelvic side a slightly marked elevation extends from the ilio-pubal eminence to the spine of the ischium, on each side of which the bone slopes in opposite directions, making the so called *planes* of the ischium. This surface is covered by the *obturator internus*. To the tip of the ischial spine is attached the lesser sciatic ligament, to the margin above it, the obturator fascia. From the outer surface where the ischial spine borders the cartilaginous area of the lesser sciatic notch, the *superior gemellus* arises (fig. 256, *G.S.*) from its inner surface the *levator ani* and *coccygeus*.

The wide posterior surface of the tuber ischii is divided by an oblique line into two areas, an outer giving origin to the *semimembranosus*, an inner to the *biceps* and *semitendinosus*. From the lower margin of the cartilage-clad area of the lesser sciatic notch arises the *gemellus inferior* (fig. 256, *G.I.*), and from the outer lip of the tuber, external to the *semimembranosus*, arises the *quadratus femoris* above (fig. 258) and part of the *adductor magnus* below. To the inner lip, often sharp and prominent on the pelvic side, the falciform border of the greater sciatic ligament and obturator fascia are attached below the **pubic groove**.

From the inferior surface of the tuber cavernosum arises the crus penis in the male, bordered below by the origin of the *ischio-cavernosus* muscle, internal to which starts the *transversus perinei*.

To the crest of the pubis are attached the *rectus* and *pyramidalis abdominis* muscles, the conjoined tendon and the *external oblique* tendon; below it and close to the angle of pubis, between the crest and the symphysis, arises the

adductor longus. From the inner margin of the anterior surface, along the lower half of the symphysis and inferior ramus, arises the *gracilis*; external to which is the origin of the *adductor brevis*, which extends down to the origin of the *adductor magnus*. The fibrous elements investing the pubic spine represent the marsupial bone of didelph mammals.

Development.—The hip-bone consists originally of an ilio-ischiatic cartilage to which a separate pubic cartilage becomes appended. Its bony tissue arises by eight centres, one for the ilium, above and behind the acetabulum, beginning early in the ninth week; one for the ischium in the superior ramus, appearing in the twelfth week; and one in the pubis internal to the ilio-pubal eminence in the fourth month. The acetabular element ossifies in the sixth year usually by a double centre in the Y-shaped cartilage which unites the three pelvic elements. This unites at about fourteen years of age with the ilium and ischium, and at fifteen with the pubis, the acetabulum being completed at about seventeen. This element may be Y-shaped like the cartilage in which it arises, but the limb between the ilium and the ischium is usually the thickest in the young male pelvis, that between the pubis and the ilium in the female. The part between the ischium and the pubis is generally thin or absent. The ischio-pubal rami unite at eight. Four separate epiphyses form, one along the crest of the ilium, ossification in which begins in two or three spots at fifteen, and it unites at twenty-one; a second over the tuber ischii, appearing at fourteen, consolidating at twenty; a third over the anterior inferior spine, appearing at sixteen, consolidating at nineteen; and a fourth over the pubic crest, appearing at seventeen, uniting at twenty-one.

In structure the hip-bone consists of a middle cancellous layer of varying thickness enclosed in a compact shell. The cancellous tissue is deficient in the middle of the iliac fossa where the bone is thinnest, it is most abundant in the tubera ilii and ischii. The outer and inner compact layers are very dense in the portion of bone joining the acetabulum and auricular facet, and in that joining the acetabulum and the tubercle of the crest of the ilium.

103. SYMPHYSIS PUBIS.—Each of the contiguous pubic surfaces at the symphysis (fig. 75) is covered by a thin layer of hyaline cartilage, and between these is a soft mass of fibro-cartilage, broader in front and below, consisting chiefly of concentric fibrous rings, and often irregularly cleft in the centre. The joint is strengthened in front by crossing bands derived from the periosteum and abdominal muscles, and by a thin fascial and periosteal expansion behind. Above and below, the uniting material becomes pure fibrous tissue, the latter

forming a **subpubic ligament** which lines and renders smooth the under edge of the arch of the pubis. The cavity occasionally found in this joint is nearer its hinder than its fore surface, is not lined by synovial membrane, rarely appears before ten years of age, and is larger in the female than in the male, although there is but little evidence that it is much affected by pregnancy.

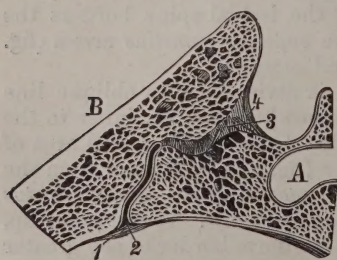


Fig. 259.—Horizontal section of sacro-iliac joint—A, sacrum; B, ilium; 1, anterior portion of sacro-iliac capsule.

104. THE SACRO-ILIAC JOINT (fig. 259) is a synchondrosis, wherein the rough ear-shaped facet of the ilium is fastened to the sacrum by an irregular fibrous capsula. The two surfaces are cartilage-clad, and united by irregular patches of fibro-cartilage, but for a considerable part of their extent they are simply in contact, and the contiguous surfaces bound a cavity (fig. 259, 2) and are moistened by a synovia-

like fluid. Posteriorly there are many strong irregular bands of **interosseous sacro-iliac ligaments** (*ib.*, 3), which form a thick mass, filling up the space between the tuberosity of the ilium and the sacrum, by which the sacrum is slung *in situ*. The surfaces are so arranged that while the sacrum projects slightly forwards, yet much of the sacral surface leans on the ilium. Over the posterior sacro-iliac fibres, which gradually lengthen from before backwards, lies a **long sacro-iliac ligament** (*ib.*, 4), which descends obliquely from the posterior iliac spine to the back of the third sacral vertebra.

As accessory ligaments to this joint are the following:—(1) **The ilio-lumbar ligament**, which is the thickened lower edge of the fascial sheath of the *quadratus lumborum*, stretching from the costal process of the fifth lumbar to the iliac crest below the origin of that muscle.

(2) **The greater sciatic ligament** is attached behind to the lower edge of the posterior gluteal area of the ilium, and to the transverse and articular processes of the sacral vertebrae by a series of irregular lamellae, partly separated by masses of fat and vessels, constituting the widest part of the ligament; from thence descending backwards and outwards it is inserted below into the inner margin of the tuber ischii, along which its *fulciform process* is continued forwards, giving attachment to the obturator fascia.

Its lower border is directly continuous into the tendon of origin of the *biceps*, of which for the most part it was originally the sacral continuation, cut off by the projection of the tubera ischii, and supplemented by the attachment thereto of the gluteal fascia.

(3) **The lesser sciatic ligament** is shown by remov-

ing the greater, on the ventral side of which it lies. It is attached by a wide base to the side of the sacrum and coccyx, and is fastened by its apex to the ischial spine. This ligament is the thickened sheath of the *coccygeus*, the diminished ischio-caudal muscle, and forms the lower boundary of the greater sciatic notch, through which the *pyriformis* muscle escapes from the pelvis. Above the pyriformis lie the gluteal vessels and superior gluteal nerve, while below it are the sciatic vessels and nerves and the pudic artery and nerve and the nerve to the obturator internus. Between the two ligaments lies the lesser sciatic notch, allowing the escape of the *obturator internus* tendon, above which the pudic artery and its two accompanying veins and nerves re-enter the pelvis.

105. PROPER LIGAMENTS OF THE HIP-BONE.—The obturator foramen is closed by the **obturator membrane**, composed of thin irregular

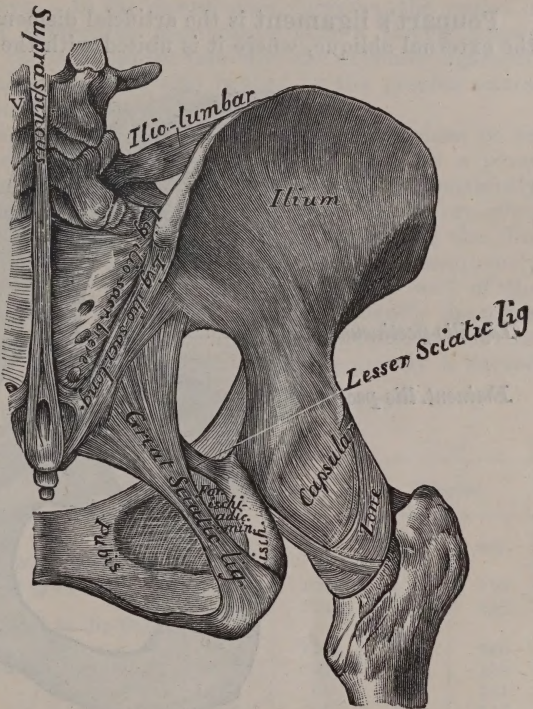


Fig. 260.—Ligaments of the pelvis seen from behind.

lamellæ of fibres mostly horizontal attached externally to the margin of the foramen, internally to a rough line on the inner border of the ischio-pubic ramus. A strong band underlies the obturator canal, stretching from the **inner** to the **outer obturator tubercle**, bounding the passage for the vessels and nerves. Externally, some superficial fibres stretch from the face of the membrane to the capsule of the hip, overlying some fat-masses which are continuous with the fatty pad in the acetabular notch. From the outer surface of the membrane and the surrounding bone arises the *obturator externus*. The area for the *obturator internus* is much more extensive.

In the periosteum clothing the inner surface of the bodies of the bones there are ligamentous fibres, the rudiments of the original ilio- and ischio-pubic bands.

Poupart's ligament is the artificial dismemberment of the lower edge of the external oblique, where it is united with the femoral and abdominal fasciæ,

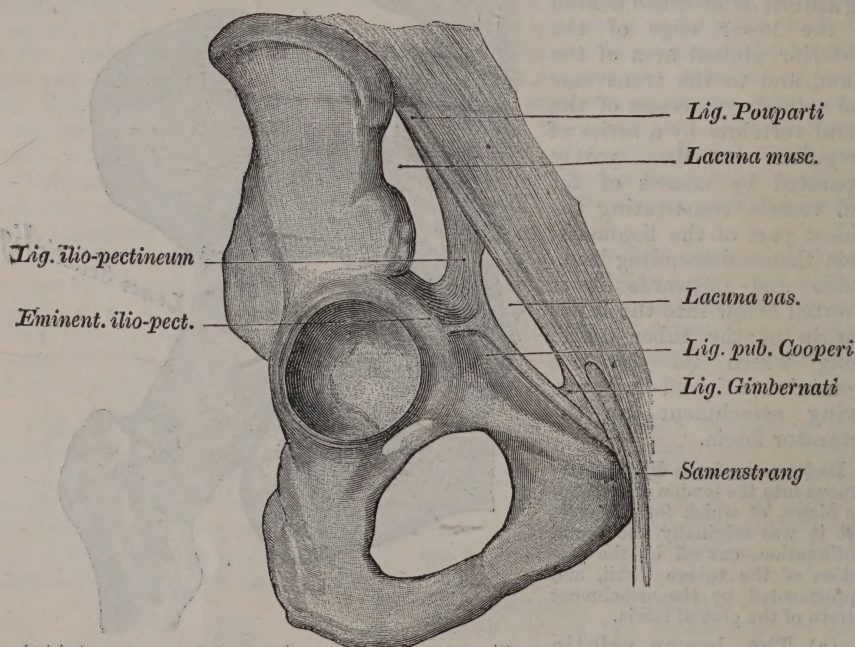


Fig. 261.--Poupart's ligament and the crural arch with its two lacunæ.

and is attached to the superior spine of the ilium, to the pubic spine, and by its reflection or **Gimbernati's ligament** (fig. 261) to the ilio-pectineal line.

On removing the more superficial part, or Poupart's ligament proper, a deeper facial band, the crural arch, can be artificially isolated. This arches over the interspace between the iliac and pubic spines, and the space beneath it is divided by a middle band (the **ilio-pectineal ligament**) into two lacunæ.

Through the outer or lacuna musculosa there escape from the pelvis the external cutaneous nerve of the thigh, the iliacus and psoas muscles, and the anterior crural nerve and the crural branch of the genito-crural nerve; through the inner or lacuna vasculosa, the femoral artery, vein, and lymphatics. From its pubic insertion there ascends upwards and inwards to the middle line a variable structure, the triangular ligament, to be subsequently described (§ 236).

The ilium articulates with its two fellow-constituents of the hip-bone, with the sacrum and femur; the other two elements articulate with the femur, the pubis also uniting with its

fellow. As a whole the hip-bone articulates with three bones, gives origin to thirty muscles (from the ilium thirteen, from the ischium fourteen, from the pubis thirteen), and the pubis gives insertion to four.

106. THE PELVIC CAVITY is obliquely placed, bounded behind by the sacrum and coccyx, and laterally by the hip-bone; above it is limited by the inlet or brim, bounded by the promontory of the sacrum, the ilio-pubal lines and pubic crests. The wide space above these between the iliac alæ is the hypogastric or lower part of the abdominal cavity, sometimes erroneously called the false pelvis. The inferior plane or outlet of the pelvis is in the dry bone very irregular, bounded by a thrice indented line, notched in front by the arch of the pubis, postero-laterally by the sciatic notches, projecting in three points at the ischial tubera and coccyx. In the recent state, however, the outlet is narrowed by the sciatic and interpubic membranes into a lozenge-shaped opening, bounded in front by the ischio-pubal rami and the subpubic ligament, on each side by the tubera ischii, on each side behind by the greater sciatic ligament, while the coccyx behind completes the boundaries.

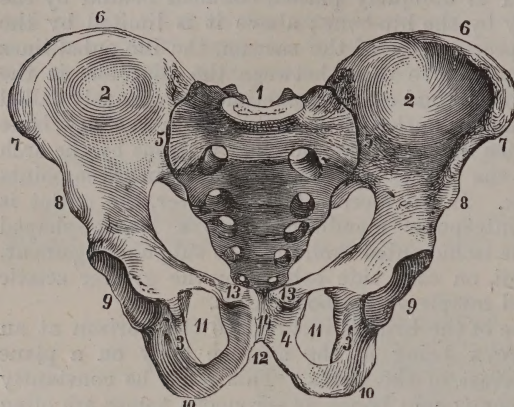
In the erect position the plane of the brim is inclined to the horizon at an angle of 60° , the tip of the coccyx being in the average body on a plane 16 mm. above the level of the crest of the pubis. This must be constantly borne in mind in examining the component bones, as erroneous names are often given to parts of these bones from the vicious system of regarding the ilio-pectineal line as if it were horizontal. The axis of the brim is consequently directed forwards and upwards at an angle of 30° . The hinder wall of the pelvis is about 14 cm. long, the front wall about 6 cm., consequently the plane of the lower outlet is much nearer the horizontal, its inclination to that plane averaging 15° . The axis of the pelvic cavity is consequently a curved line concave forwards.

The average dimensions of the pelvis are as follows :—

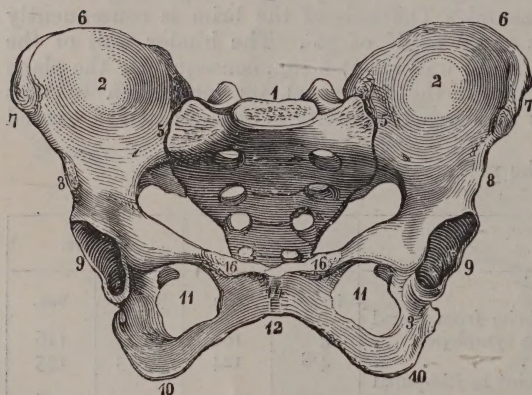
	Males.		Females.	
	inches.	mm.	inches.	mm.
Conjugate or sagittal diameter of brim from sacral promontory to upper edge of pubic symphysis, . . .	4	100	4'5	116
Transverse diameter of brim,	4'8	124	5'13	135
Oblique diameter from sacro-iliac joint to ilio-pubal eminence,	4'3	110	5	126
Conjugate or sagittal diameter of outlet,	3'7	95	5	126
Transverse diameter of outlet,	3'2	81	4'7	121
Oblique diameter of outlet,	3'5	90	4'5	115
Average height of anterior wall or symphysis, . . .	2	53	1'7	45
Average height of lateral wall from ilio-pubal line to tuber ischii,	4'2	108	3'7	96
Average height of posterior wall,	5'5	140	5'0	128
Angle of pubis,	...	75°	...	96°
Conjugate at mid point of cavity,	4'2	108	5'12	132
Oblique at mid point of cavity,	4'7	122	5'3	135
Transverse at mid point of cavity,	4'7	120	5	126
Grreatest transverse diameter between iliac crests, . .	10	256	10	257
Interval between the superior iliac spines,	9'5	243	9'5	243
Height from iliac crest to ilio-pubal line,	4	102	4	88
Angle of mid plane of symphysis pubis with conjugate diameter,	...	94°	...	96°
External conjugate from outside of symphysis to spine of last lumbar,	7	176	7'2	183
From same to third sacral spine,	5'8	169	6'3	162

The pelves of the two sexes present many points of contrast. The male pelvis is deeper, rougher, with deeper iliac fossæ and symphysis, a smaller pubic angle, a vertically ovate obturator foramen, and inflexed tubera ischii.

The female pelvis is shallower, wider, smoother, with shallower symphysis and wider pubic arch, everted ischia, and a triangular obturator foramen. These sex characters are discernible even at birth.



Male pelvis.



Female pelvis.

Figs. 262, 263.—1, Sacrum; 2, iliac fossa; 3, superior ramus of ischium; 4, inferior ramus of pubis; 5, sacro-iliac synchondrosis; 6, crest of ilium; 7, superior iliac spine; 8, inferior; 9, acetabulum; 10, tuber ischii; 11, obturator foramen; 12, arch of pubis.

the head, and giving attachment to the ligamentum teres. The head is directed upwards, inwards, and a little forwards, and is supported on a sagittally-compressed **neck** which joins the shaft below at an angle of 125° . At its confluence with the shaft there project two prominent knobs, the **trochanters**, for the attachment of the rotator muscles, the **greater** being above and external, having an inflexed apex posteriorly overhanging a deep pit, the **digital fossa**, into which the *obturator externus* tendon is inserted. From the inflexed apex (fig. 266) downwards and forwards the trochanter is crossed by a broad, oblique band for the attachment of the *gluteus medius*, behind which it is covered by the *gluteus maximus*, while in front it is rough for the insertion of the *gluteus minimus*. Above the digital fossa is a shallow pit for the tendon of the *obturator*

The age-changes in the pelvic bones themselves are three-fold. The splay of the ala of the ilium forms with the wall of the true pelvis in the infant an angle of about 137° ; this increases to 145° in childhood, but in the adult male the angle becomes 153° , in the female 155° . The depth of the cavity of the true pelvis likewise increases steadily from infancy to maturity. The extent of the tuberosity of the ilium is small in the infant, but increases largely in the last few years of adolescent life. In the lower races it often maintains its infantile smaller size. The pelvic brim-index $\frac{\text{sagittal} \times 100}{\text{transv. diam.}}$ varies in different races. That of the average European male is 82.5, of the negro 88, of the Australian 94, of the Bush-races of Africa 90, of the Andamanese 96. Pelves with an index under 85 are *platypellic*, those over 85 are *dolichopellic*.

107. THE FEMUR.—The thigh bone is the strongest and longest bone in the body, and articulates with the hip-bone above, the patella in front, and the tibia below. Its **head** forms five-ninths of a sphere, and is covered with cartilage, except at a small pit or **fovea capitis** situated below and behind the axis of

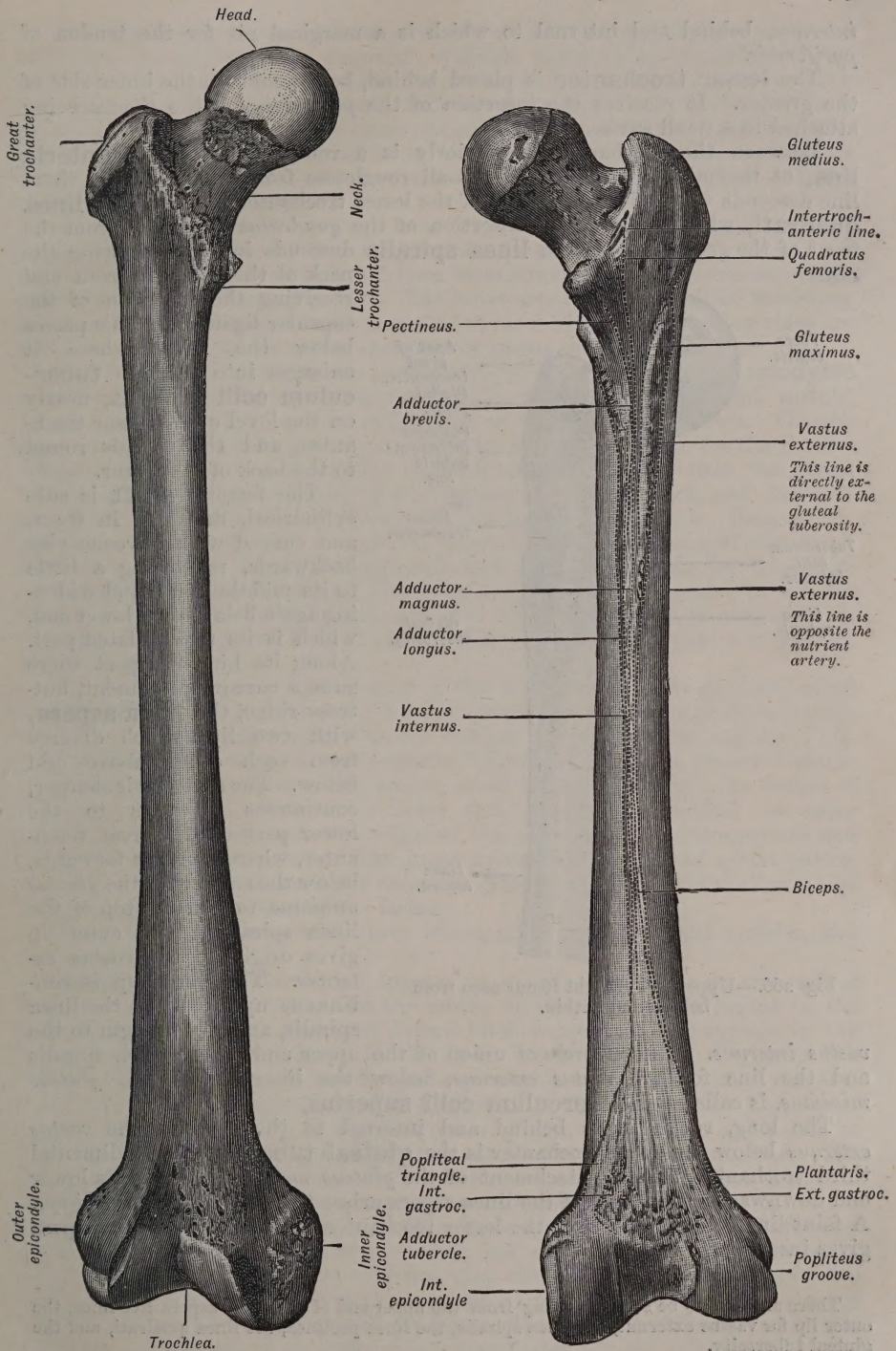
Fig. 264.—Right femur, front surface, $\frac{2}{3}$.

Fig. 265.—Femur, back view.

internus, behind and internal to which is a marginal pit for the tendon of *pyriformis*.

The **lesser trochanter** is placed behind, below, and on the inner side of the greater. It receives the insertion of the *psaos* tendon, the *iliacus* being attached to a small surface below it.

Between the trochanters posteriorly is a rounded **intertrochanteric line**, at the middle of which is a small roughness from which a faint, short line descends vertically to the level of the lesser trochanter. This is the **linea quadrati**, which receives the insertion of the *quadratus femoris*. From the front of the great trochanter a **linea spiralis**

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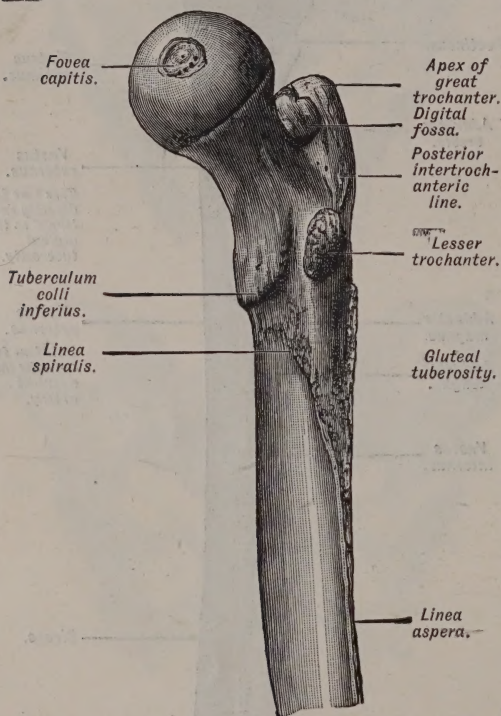


Fig. 266.—Upper end of right femur seen from behind and within.

descends inwards, limiting the neck of the femur in front and receiving the insertion of the capsular ligament. This passes below the neck, where it enlarges into a rough **tuberculum colli inferius**, nearly on the level of the lesser trochanter, and then winds round to the back of the femur.

The femoral **shaft** is subcylindrical, flattened in front, and curved with its concavity backwards, narrowing a little to its middle third, and widening again below to its lower end, which is its most dilated part. Along its hinder aspect there runs a narrow, prominent, buttress ridge, the **linea aspera**, with two lips which diverge from each other above and below. The outer lip is sharper, continuous upwards to the lower part of the great trochanter, where it turns forwards, below the surface for the *gluteus minimus*, to join the top of the linea spiralis. This outer lip gives origin to the *vastus externus*. The inner lip is continuous upwards into the linea spiralis, and gives origin to the

vastus internus. The tubercle of union of the upper end of the linea spiralis and the line for the *vastus externus*, below the insertion of the *gluteus minimus*, is called the **tuberculum colli superius**.

The long, rough space behind and internal to the line for the *vastus externus* below the great trochanter is the **gluteal tuberosity** or rudimental third trochanter, for the attachment of the *gluteus maximus*. From its lower end downwards to the end of the linea aspera arises the *short head of the biceps*. A faint line behind and below the lesser trochanter leading to the linea aspera gives insertion to the *pectineus*.

There are thus to be seen diverging from the upper end of the linea aspera five lines, the outer lip for *vastus externus*, the linea spiralis, the linea pectinea, the linea quadrati, and the gluteal tuberosity.

Into the narrow space between the *vastus internus* and the short head of the *biceps* the *adductors* are inserted; *adductor longus* being the closest to the *vastus* for the middle third of the femur; *adductor brevis* behind and above for the upper third of the *linea aspera*; *adductor magnus* for its whole length from below the *linea quadrati* to the inner epicondyle. It should be remembered by the student that much of the adductor insertion is confluent with the internal intermuscular septum, so that separate lines do not exist for these muscles along the shaft of the bone.

At the lower fourth of the thigh bone the *linea aspera* ends by the divergence of its lips, which bound between them the **popliteal triangle**; the inner of the two lips is here rounded off for a considerable part of its extent, where it is crossed by the femoral artery. The inner aspect of the shaft of the femur is smooth, and gives origin to no muscular fibres. The front and outer sides are rougher, and gives origin to the *crureus* and *vastus externus*.

The lower extremity presents posteriorly two ovoid, cartilage-clad **condyles** to articulate with the tibia, separated by a deep **intercondyloid notch**, whose sides are rough for the attachment of the crucial ligaments. On the front surface the two condyles are confluent into a **trochlea** for the patella, whose outer side is larger, farther forward, and rises higher than the inner. Of the two condyles, the inner is the longer, the farther back, and descends the lower when the bone is held with its long axis vertical. During life, however, the two condyles are on the same level, and the axes of the thigh bones are oblique, directed downwards and inwards, so that the knees are closer together than the hips. The degree of obliquity is greater in females than in males. This obliquity is correlated with the need which exists during walking of bringing each limb alternately into the line of the centre of gravity of the body.

At the lower end of each branch of the *linea aspera* there is a projecting **epicondyle**. Of these the inner is larger, rounder, and bears above a supra-condyloid or **adductor spur** for the tendon of the *adductor magnus*. The outer epicondyle is rougher, and presents, below and behind, a groove directed upwards and backwards to accommodate, when the knee is flexed, the tendon of the *popliteus*, which arises at its lower end. Above and behind the outer condyle is a rough area for the origin of the *outer head of gastrocnemius* and *plantaris*. Above and behind the inner arises the *inner head of the gastrocnemius*. The origin of the latter extends nearer to the middle of the bone, and is more tuberosous than that of the former.

The femur articulates with three bones, gives origin to eight muscles, and insertion to fifteen.

Development.—The femur appears as a rod of cartilage at the end of the third week of foetal life. In the centre of this, ossification begins in the seventh week. About a fortnight before birth a bony nucleus appears in the lower end (the only epiphysis in the body whose ossification begins before birth). Ossification begins in the head ten months after birth; in the greater trochanter in the fourth year; in the lesser in the thirteenth. The lesser trochanter joins the shaft at eighteen years of age, the greater trochanter at eighteen and a-half, the head at nineteen, the lower end at twenty-one. The neck is an upward extension of the shaft, and separates the head from the trochanters, which do not coalesce into a single upper epiphysis as in the humerus. At birth the neck is small and undeveloped; set on the shaft at an angle of about 160° . The female adult has a lower angle than the male, averaging 118° . There is no evidence that the neck angle alters appreciably after maturity is attained, but the amount of the angle is subject to much variety. When the angle is small the inner edge of the shaft below it becomes flattened and appears as an internal bearing-pilaster.

The greater trochanter, the epicondyles, and the edges of the trochlea are palpable during life. The top of the trochanter is 2 cm. below the level of the head of the bone, and nearly on the level of the pubic spine, and 7.5 cm. below the iliac crest.

The nutrient artery of the shaft is a branch of the middle perforating artery, and enters near the middle third of the linea aspera. The head is nourished by branches of the sciatic artery, which enter posteriorly; the great trochanter by a branch of the internal circumflex. The condyles are pierced by many holes for branches of the superior articular arteries.

The femur makes .274 of the stature in individuals of average height; in very tall men it is about .277; in small men .272. The curve of the head departs a little from the perfectly spherical; most sagittal sections represent circles of 1 mm. radius shorter than horizontal sections (26.5 : 27.3).

The cartilage clothing the head does not end in an even line, but its margin is indented by a notch above, by one in front, and one behind.

The axis of the neck is inclined to the median plane at an angle of 70° , that of the condyles at an angle of 82° , showing that the bone has been twisted through an arc of 12° .

The curves of the two condyles are remarkable and dissimilar; that of the section along the axis of the outer condyle is a logarithmic spiral having a common ratio of 3.7. The curve of this condyle subtends an angle of 270° , and has anteriorly a radius vector of 45 mm. at 180° of 28.5 mm., posteriorly of 16 mm. The inner condyle has a curve of 230° , with a radius vector anteriorly of

33 mm., posteriorly of 18 mm. It is especially in the curves of their anterior third that the condyles differ. In consequence of this for the first third of flexion of the knee, the motion is a rotation of the tibia around the axis of a cone.

The cancellous tissue of the head and neck of the femur shows strongly marked pressure planes starting in a radiating manner from the inner circumference of the shaft, and ascending to the top of the head (figs. 65 and 66, A,A). From the outer wall a similar series of planes ascend in the upper part of the neck to the head. These are intersected by a series of strong

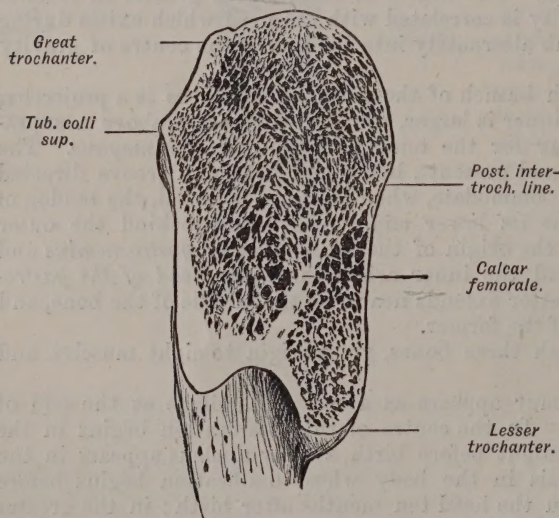


Fig. 267.—Calcar femorale, shown by section through the neck of the femur.

tension planes (fig. 66, B). Some of these latter are the lines along which muscles and ligaments exert their traction (C,D,E,F,G,H,I), and the whole series is one of the most beautiful arrangements of orthogonal cancelli in the body. The cancelli in the head are round-meshed. Projecting into the interior, from the tuberculum colli inferius, is a nearly vertical plane of compact bony tissue, the *calcar femorale* (fig. 267); which extends towards the gluteal tuberosity. This is placed in the line through which the weight of the body falls, and forms an important element in the stability of the femoral neck. It

is liable to absorption in old age, and the neck of the bone then becomes proportionally weakened.

In the lower end of the femur the cancellous planes are perpendicular and horizontal, and form a series of rectangular meshes. In certain races the backward concavity of the femoral shaft is exaggerated, and the *linea aspera* is very prominent, the bone becoming a flanged pillar having its solid *rib* on the concave or compression side, and its wide front on the convex or tension side. Such a femur is said to be *pilastered*. The same kind of mechanical necessity causes an increase of transverse width and a diminution of sagittal thickness below the lesser trochanter in femora of certain curvatures.

Beside the character of the head and neck above referred to (§ 89), the femur differs from the humerus in the expansion of the extensor aspect, in the corresponding reduction in the flexor area to the interval between the lips of the *linea aspera*, in the direction of the nutrient foramen, and the reduction of the distal articulation to one for the preaxial bone of the leg only.

108. THE HIP-JOINT is an enarthrodia wherein the ball of the femoral head is tightly held in its socket. Around it are strong muscles, in front the *psaos* and *iliacus*; internally, the *pectineus* and *obturator externus*; behind, the *quadratus femoris*, *obturator internus*, and its two accessory *gemelli*, and the *pyriformis*; and externally, the *gluteus medius* and *minimus*, and *rectus femoris*.

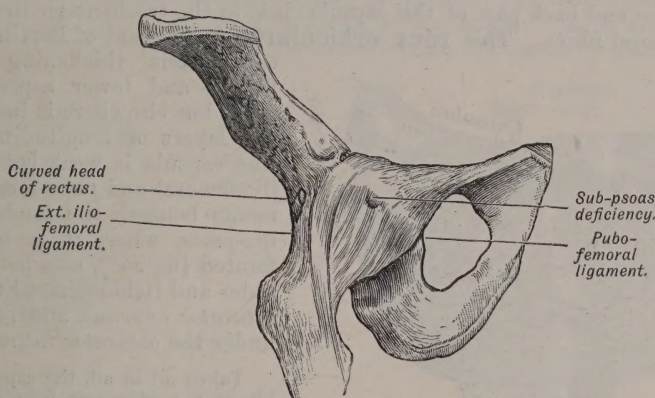


Fig. 268.—Anterior surface of hip-joint showing ilio-femoral and pubo-femoral ligaments.

The fascial sheaths of some of these muscles dipping inwards become attached in the intermuscular intervals to the capsule of the joint, making a series of external accessory strengthening bands which are often described as accessory ligaments, although they are quite inseparable from the rest of the capsule (fig. 268). The strongest of these bands is the **ligamentum ilio-femorale** (fig. 268), a widely triangular structure attached to the sheath of the *iliacus* internally, and to that of the *gluteus minimus* externally, and passing from the brim of the acetabulum below the inferior spine to the tuberculum colli inferius and spiral line, as high as the insertion of the *gluteus minimus*.

This is the strongest part of the capsule, and serves to restrict extension and eversion. When the femoral head is forcibly driven backwards this band acts as a fixed axis, around which the bone is made to rotate, so directing the dislocated head of the femur towards the dorsum of the ilium. It is seldom torn in a simple dislocation. The upper and inner fibres which are connected to the fibres of the *iliacus*, and the lower which are closely connected externally to the tendon of the *gluteus minimus*, are stronger than those intermediate, and are sometimes described as if separable from the rest of the capsule and from

each other, under the name of the **Y-shaped ligament of Bigelow**. The upper and outer band was originally described as the external ilio-femoral ligament.

The fascia between the *pectineus* and *obturator externus*, at its insertion into the capsule, makes a prominent but weak internal accessory band, the **pubo-femoral ligament**, which is attached to the ilio-pectineal eminence and to the tuberculum colli inferius.

This ligament is often laminated, with fat between its layers, and is continuous into the superficial part of the obturator membrane.

Posteriorly, the fascia between the *obturator externus* and *gemellus inferior* makes, by its attachment to the capsule, the **ischio-femoral ligament**, a variable thickening in the back of the capsular ligament attached on the one side to the ischiatic sub-acetabular groove, and on the other partly to the zonary fibres of the capsule (the *ischio-capsular part*), partly into the femur above the digital fossa.

Beneath, but inseparable from these, is the **capsule proper**, consisting of two sets of fibres, one direct, arising from the outside of the edge of the acetabulum, and inserted into the anterior *linea spiralis* and by very weak fibres into the back of the neck of the femur. The second series consists of a band of ring-like fibres which arise with the longitudinal fibres of the ilio-femoral ligament and arch round under the neck of the femur, becoming lost on the upper and back part of the capsule close to the trochanteric insertion of the ilio-femoral fibres. This **zona orbicularis** or ligament of Bertin makes a

conspicuous thickening on the hinder and lower aspect of the neck, but elsewhere is included in the layers of longitudinal fibres. The capsule is weak between the ilio-femoral and pubo-femoral ligaments beneath the tendon of the *ilio-psoas*, where it is often perforated (fig 268), also between the pubo- and ischio-femoral under the *obturator externus*, and posteriorly under the *obturator internus*.

Taken all in all, the capsule of the hip is the strongest ligament in the body; and is capable of sustaining a weight of 450 kilos.

On dividing the capsule by a circular incision, the head of the thigh bone is retained in its socket by atmospheric pressure, the retaining force of which is able to sustain a weight of 20 kilos., a

little more than the weight of the limb. This is due to the socket being deepened by a fibro-cartilaginous **cotyloid lip** which is attached around the edge of the acetabulum, its outer surface lying in contact with the capsule, its inner with the head of the femur; its attached border is thick, and its free border is thin.

The latter makes a circle of about 24 mm. radius, while the inner edge of the former is a circle of about 25 mm., and the equator of the head of the femur has a radius of 24.5 mm. These proportions hold, even when the numbers vary.

At the cotyloid notch the deeper fibres of the cotyloid lip stretch from side

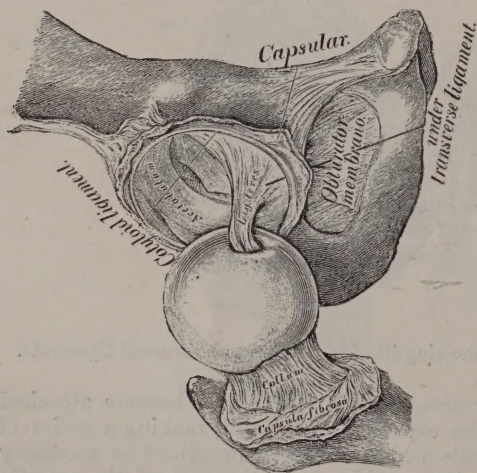


Fig. 269.—Interior of hip-joint shown by division of the capsular ligament.

to side, converting it into a foramen under which the fat of the fossa acetabuli projects, and the articular arteries from the obturator and internal circumflex enter into the joint. These bridging fibres, which differ in structure from the cotyloid in having no nests of cartilage cells among them, are usually known as the *transverse ligament*. The fibres of the cotyloid lip are not parallel to the acetabular edge but pass from without inwards, interlacing in the thickness of the lip. From the femoral attachment of the capsule strong flat reflected bands pass towards the margin of the head of the bone lying on the neck—one strong band passes inwards and backwards from the tuberculum colli superius, a second from the tuberculum colli inferius, and a third from the vicinity of the lesser trochanter. These are called the *retinacula* of *Weitbrecht* (fig. 269, *collum*).

The **ligamentum teres**, neither a ligament nor round, is a flattish band of synovial membrane, with a narrow insertion into the fovea capitis of the femur and a wider attachment to the margin of the acetabular notch, the transverse ligament and the acetabular cushion of fat. It consists of a layer of synovial membrane on a fairly firm connective basis, enclosing a soft vascular central core. This band is sufficiently long to allow the head of the femur to be drawn out of the socket, but not long enough to allow it to be displaced outside the acetabular edge, consequently it must be torn in every dislocation. It ruptures with a stress of about 14 kilos., and is consequently useless as a ligament. Several minute vessels enter it, especially from the obturator artery, and a few of these pass into the head of the femur. It is made tense by semiflexion, adduction and rotation inwards, and is relaxed by abduction.

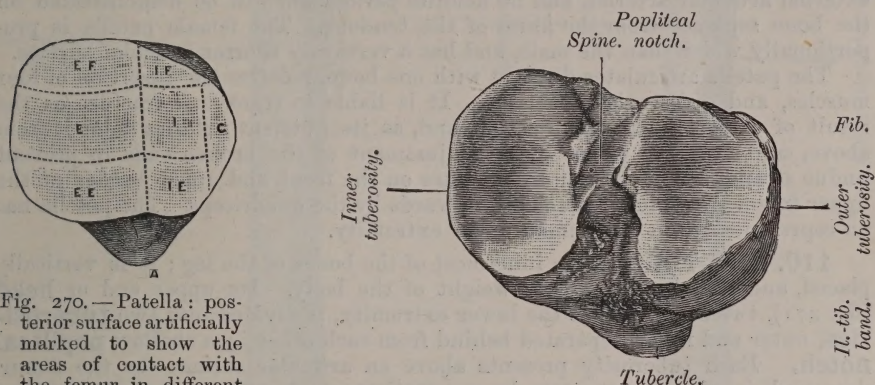


Fig. 270.—Patella: posterior surface artificially marked to show the areas of contact with the femur in different positions of the knee.

Fig. 271.—Upper surface of left tibia, $\frac{1}{2}$.

The ligamentum teres was originally a portion of the inner synovial wall of the capsule of the joint, which has become isolated by the extension of the ischiatic articular surface. This extension is correlated to the increased need of rotation in the joint. In the shoulder, where the corresponding coracoid element is but slightly articular, the homologous fold is still marginal.

Motion in the hip-joint is free in all directions, the range from abduction to adduction being 90° , from flexion to extension 140° . Extension beyond the right line is prevented by the ilio-femoral part of the capsule and the zona orbicularis which also restrict rotation. Flexion is limited by the contact of the anterior soft parts and by the hamstrings when the knee is extended; abduction is limited by the adductor muscles and pubo-femoral ligament.

Comparing the hip with the shoulder, it will be noted that in the former motion around a sagittal axis can take place through 90° , in the latter through 118° . In the hip, motion around a coronal axis can be carried through an arc of 140° ; in the shoulder of 170° . In the hip rotation around a vertical axis can be carried through 45° ; in the shoulder through 90° . In the upright position of the body the plane of the centre of gravity is behind that of the axes of rotation of the two hip-joints.

109. THE PATELLA is a large flattened sesamoid bone, triangular in shape, with its apex downwards, placed in the front of the capsule of the knee, receiving at its base the insertion of the *extensor cruris* muscle, and lying on the trochlea of the femur. Its anterior surface is longitudinally striated, covered only by skin, fascia, and bursæ, and pierced by vessels; its posterior surface is covered by articular cartilage, except at the lower angle, and is divided by a vertical ridge into two surfaces, of which the outer is the larger. The apex is rough for the attachment of the ligamentum patellæ on its deeper surface.

The patella is never in contact by its whole articular surface with the femur; in extreme extension only its inner strip and a small area at its lowest part on each side of the middle ridge touches the trochlea (fig. 270, **EE** and **IE**), in extreme flexion of the knee only the inner strip of permanent contact and the upper part touches the femur (*ib.*, **EF** and **IF**); in the mid-state an intermediate area lies on the bone (*ib.*, **E, I**). For these contacts the articular surface is divided into seven facets by two faint transverse and two vertical lines; the faint inner vertical line cuts off a narrow internal strip (*ib.*, **C**), which lies on the femur in all positions; the outer vertical line is the middle ridge, the lower transverse line isolates the extension area, the upper the flexion area.

The edges of the patella are thinner than the middle, and give attachment to the anterior spurious part of the knee capsule and part of the vasti tendons; the base is oblique, receiving the central part of the *quadriceps extensor cruris*.

Development.—The patella appears as a nodule of cartilage during the fourth month of fetal life, but does not begin to ossify until the end of the second year. Its vessels are derived chiefly from the superior internal and external articular arteries, and no definite periosteum can be demonstrated on the bone separate from the fibres of the tendons. The female patella is proportionally wider than the male, and has a vertically shorter articular surface.

The patella articulates directly with one bone, receives the insertion of four muscles, and gives origin to none. It is liable to transverse fracture as the result of excessive muscular action, and, as its nutrient arteries enter it from above, care must be taken in the adjustment of the broken ends to prevent undue strangulation of these by pressure on the front and upper border of the upper fragment, which is displaced upwards by the quadriceps. The patella has no representative in the human upper extremity.

110. THE TIBIA is the innermost of the bones of the leg; it is vertically placed, and sustains the whole weight of the body. Its upper end or **head** (fig. 271), twice as broad as the lower extremity, is divided into two **tuberosities**, outer and inner, separated behind from each other by a shallow **popliteal notch**. Each tuberosity presents above an articular surface for the femur, deepened in the recent state by a **semilunar cartilage** (fig. 283), whose cornua are attached in front and behind an irregularly bifid middle projection, **the spine**, on either surface of which the articular facets are prolonged. The outer of these articular surfaces extends the farther forward, is almost round and slightly convex in the recent state, or nearly flat. The inner extends the farther backwards, is sagittally elongated and slightly concave. Between these articular surfaces are **depressions for the crucial ligaments**, in front and behind the spine. Anterior to these is a rough surface covered by fat, and a bursa, below which in the middle line in front is a prominent **tubercle**, into which the ligamentum patellæ is inserted. The inner side of the inner tuberosity is marked behind by a groove for the *semimembranosus* tendon. The outer has a prominent anterior projection close to its edge for the attachment of the ilio-tibial ligament (fig. 271, *Il.-tib.*), and it bears below and behind a small articular facet, directed downwards and backwards, for the fibula (*ib.*, *Fib.*).

The **shaft** is triquetrous for the upper two-thirds, its **inner surface** being flat and subcutaneous, only giving attachment at its upper part by short linear

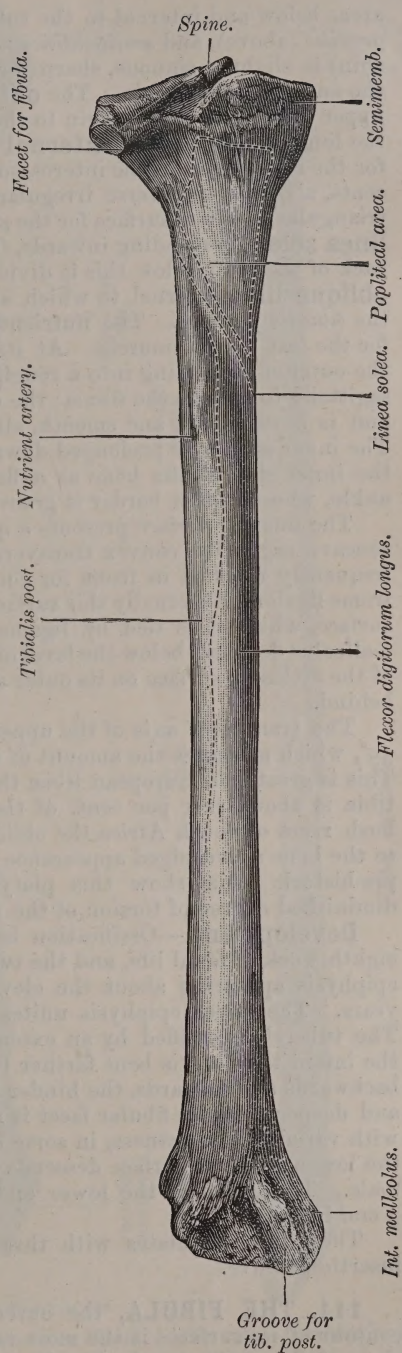
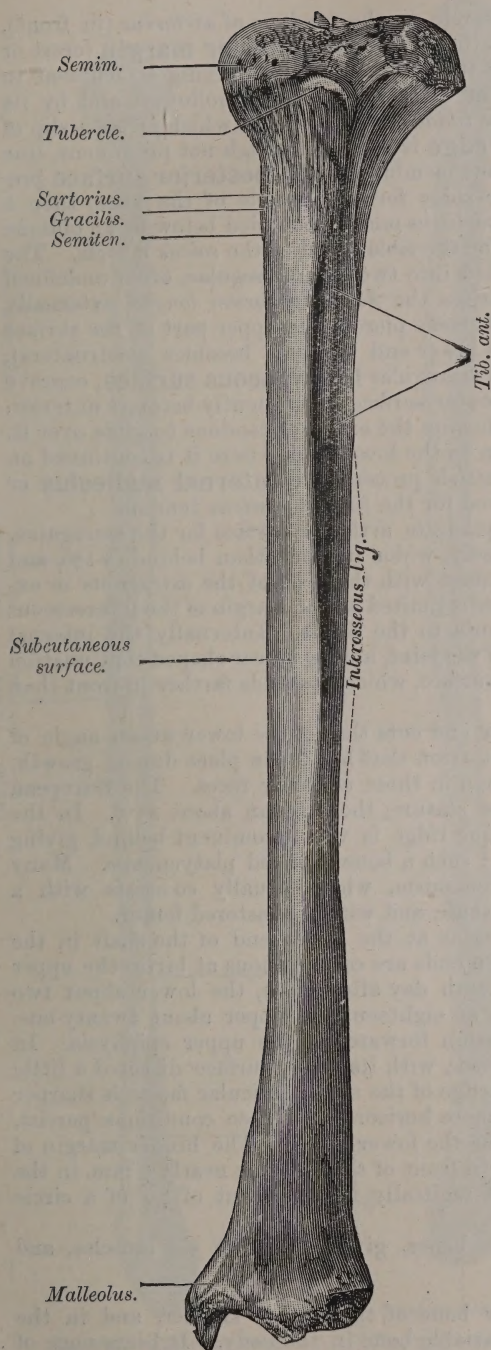
Fig. 272.—Anterior surface of left tibia, $\frac{3}{4}$.

Fig. 273.—Posterior surface of left tibia.

areas below and internal to the tubercle, to the tendons of *sartorius* (in front), *gracilis* (above), and *semitendinosus* (below). The **anterior margin** (crest or shin) is slightly sinuous, sharp for its upper two-thirds, giving attachment to the anterior tibial fascia. The **outer surface** is slightly hollowed, and by its upper two-thirds gives origin to the *tibialis anticus*, above which arises a slip of the long extensor. The **external edge** is a sharp, though not prominent, line for the attachment of the interosseous membrane. The **posterior surface** presents, above, a transverse irregular ridge for the capsule of the knee, then a triangular popliteal surface for the *popliteus* muscle, bounded below by an oblique **linea solea**, descending inwards, for the tibial head of the *soleus* muscle. The back of the shaft below this is divided into two by an irregular, often undefined **oblique line**, internal to which arises the *flexor digitorum longus*, externally the *tibialis posticus*. The nutrient artery pierces the upper part of the surface for the last named muscle. At its lower end the tibia becomes quadrilateral, the outer edge dilating into a rough triangular **interosseous surface**, concave sagittally to receive the fibula; the outer surface consequently becomes anterior, and is here convex and smooth, allowing the extensor tendons to glide over it. The inner surface is prolonged down to the lower end, where it is continued on the inner side of the bone as a flattish process, the **internal malleolus** or ankle, whose hinder border is grooved for the *tibialis posticus* tendon.

The inferior surface presents a quadrate articular surface for the astragalus, concave sagittally, convex transversely, wider in front than behind (6 : 7), and frequently notched in front for contact with the neck of the astragalus in extreme flexion. Externally this surface is limited by the margin of the interosseous surface, where it is tied by ligaments to the fibula. Internally the internal malleolus descends below the level of the joint, having an ear-shaped continuation of the articular surface on its outer surface, which descends farther in front than behind.

The transverse axis of the upper end cuts that of the lower at an angle of 35°, which measures the amount of torsion that has taken place during growth. This is greater in European tibiae than in those of lower races. The European tibia is about 22·1 per cent. of the stature, the African about 23·3. In the bush races of South Africa the oblique ridge is very prominent behind, giving to the bone a two-edged appearance; such a bone is called platynemic. Many pre-historic tibiae show this platynemism, which usually co-exists with a diminished degree of torsion of the shaft, and with a pilastered femur.

Development.—Ossification begins at the upper end of the shaft in the eighth week of foetal life, and the two ends are cartilaginous at birth, the upper epiphysis appearing about the eleventh day after birth, the lower about two years. The lower epiphysis unites at eighteen, the upper about twenty-one. The tubercle is ossified by an extension forwards of the upper epiphysis. In the infant the head is bent farther back, with its upper surface directed a little backwards and upwards, the hinder edge of the upper articular facets is sharper and deeper, and the fibular facet is more horizontal. These conditions persist, with variable distinctness, in some of the lower races. The hinder margin of the lower articular surface descends in front of the anterior nearly 7 mm. in the male. The curve of the lower end sagittally is a segment of 70° of a circle 3 cm. in radius.

The tibia articulates with three bones, gives origin to six muscles, and insertion to five.

111. THE FIBULA, the outer bone of the leg, is slender, and in the contour of its surfaces is the most variable bone in the body. It bears none of the weight of the trunk, but is preserved from atrophy for the sake of the muscles to which it gives origin, and for the part it takes in the formation

FIBULA.

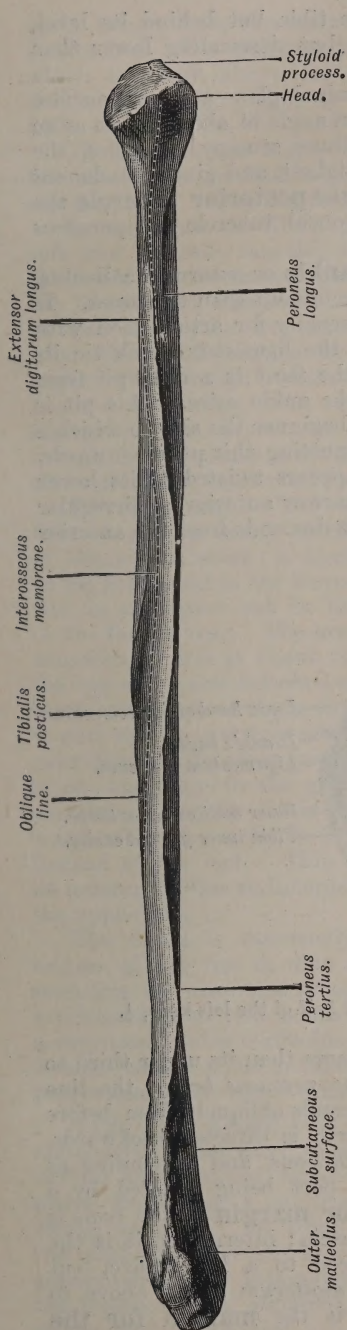


Fig. 274.—Anterior surface of left fibula, $\frac{1}{4}$.

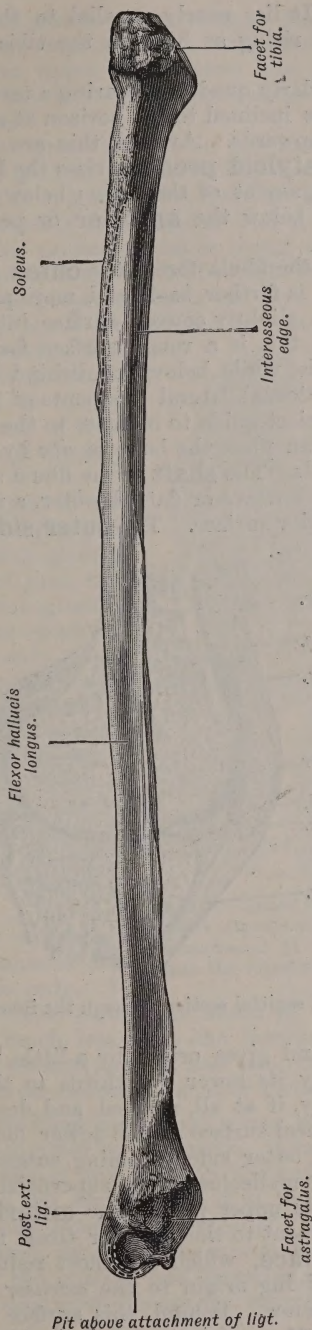


Fig. 275.—Inner side of left fibula, $\frac{1}{4}$.

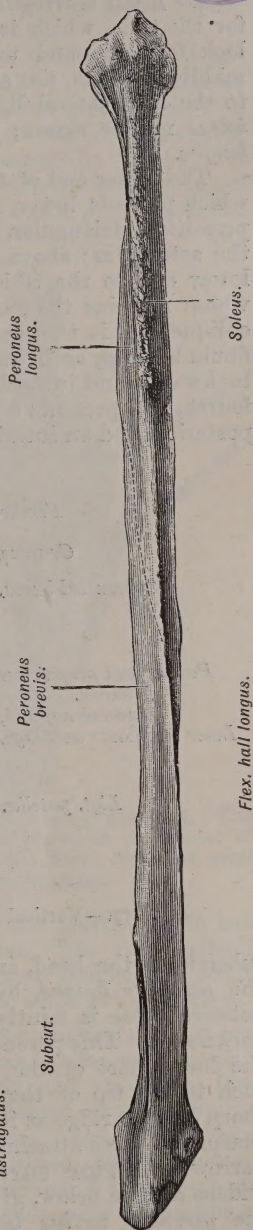


Fig. 276.—Posterior and outer surfaces of left fibula, $\frac{1}{4}$.

of the ankle-joint. It lies nearly parallel to the tibia but behind its level, especially above, not rising as high as the tibia but descending lower than that bone.

Its **head** is irregularly quadrate, bearing a terminal plane articular surface for the tibia, which is inclined to the horizon at an angle of about 40° so as to look forwards and upwards. Around this are three stumpy tubercles, the middle of which, the **styloid process**, rises the highest, and gives attachment to the outer lateral ligament of the knee; below the **posterior tubercle** the *soleus* muscle arises; below the **anterior** or peroneal tubercle the *peroneus longus*.

The lower end of the fibula forms the **outer ankle** or external malleolus, which projects lower, is farther back, and more prominent than the inner. It presents a triangular, slightly convex surface internally for articulation with the astragalus; above this is a rough surface for the ligaments which tie its lower end to the tibia, while below and behind the facet is a deep pit from whose margins the external lateral ligaments of the ankle arise. This pit is oblique, and is the easiest guide to indicate to the beginner the side to which a fibula belongs, as he can place the bone *in situ* by putting this pit downwards, backwards, and inwards. The **shaft** of the fibula appears twisted at its lower fourth, and presents a concave or flattish outer, a narrow anterior, an irregular posterior, and an interior surface. The **outer side** descends from the anterior

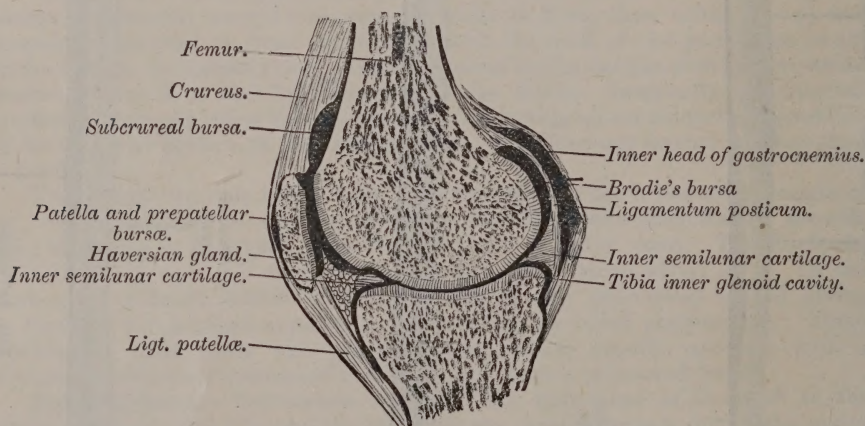


Fig. 277.—Vertical sagittal section through the inner half of the left knee, $\frac{1}{2}$.

tubercle of the head, and gives origin by a little more than its upper third to the *peroneus longus*, by its lower two-thirds to the *peroneus brevis*, the line between these is faintly, if at all, marked, and descends obliquely from before backwards. This peroneal surface at the lower fourth is directed backwards, the lower part of the outer side becoming subcutaneous, and continuing as such to the tip of the malleolus: this superficial part being isolated by a sharp oblique ridge at its upper part. The **anterior margin** of the bone is sharp, and gives attachment to the anterior tibial fascia; internal to it is the narrow **anterior surface**, which is almost reduced to a line above, but widens a little below, giving origin to the *extensor digitorum longus* above, to the *peroneus tertius* below. Behind this surface is the **margin for the interosseous ligament**, a faintly marked ridge from which, in front, a few fibres of the *extensor hallucis proprius* arise, behind which is the inner surface, very narrow above, wide and concave intermediately, and narrowing

again below, from the most of which to the oblique line the *tibialis posticus* is attached. The **oblique line** separates this from the **posterior surface**, which is rough above for its upper fifth below the posterior tubercle of the head, giving origin to the *soleus*; for its lower two-thirds the *flexor hallucis* arises from this surface.

The surfaces and angles are scarcely alike in any two fibulae, as there are few mechanical limitations to protect it from being moulded by the muscles attached to it. Even in those of opposite sides there are often differences.

In structure the fibula presents at its upper end a series of rectangular soft and delicate cancelli, the pressure planes being especially weak. At the lower end the tension planes are strong, and radiate from the attachment of the tibio-fibular ligaments; the pressure planes are here weak, and where the compact shaft joins the cancellous lower end the bone is very apt to give way when the ankle-joint is twisted. The upper end, though weak, is so little exposed to injury that it is rarely fractured. The commonest seat of fracture is the lower end of the shaft directly above the outer malleolus.

Development.—The shaft of the fibula begins to ossify at the early part of the eighth week; a nucleus appears in the lower end in the second year, and one in the upper end in the beginning of the fourth year. The lower epiphysis consolidates first at about twenty, while the upper remains detached until twenty-three. It is interesting in this connection to note that the nutrient artery in general runs downwards, consequently the fibula is an exception to the general rule of correlation, as the lower epiphysis towards which it runs is the first to appear, instead of the last. This is explicable on account of the rudimentary nature of the upper end.

The fibula is essentially a bone of origins, giving rise to nine muscles and receiving the insertion of one only. It articulates with two bones. The embryonic fibula in the fourth month has a very small outer malleolus much less than the internal. The two malleoli become nearly equal in the seventh month, and the outer assumes its adult proportion to the inner within the second year after birth while yet unossified.

112. THE KNEE is a modified ginglymus whose bony articular faces are not congruent but fitted to each other by soft parts. It has the largest articular surface and synovial membrane of any joint in the body, and though in few places more than 1 cm. from the surface, yet it is protected superficially by strong tendons. In front the *quadriceps*, externally the *biceps*, posteriorly the *popliteus*, *outer gastrocnemius*, *plantaris*, *inner gastrocnemius*, *semitendinosus*, *semimembranosus*; internally the *gracilis*, and *sartorius* surround it. Of these the *gastrocnemius*, *plantaris*, and *sartorius* are the only ones with fleshy fibres at the level of the joint.

The knee consists primarily of two morphologically distinct joints, the femoro-tibial and the femoro-patellar. In man the two are inseparable, the capsule of the knee being deficient under the patella.

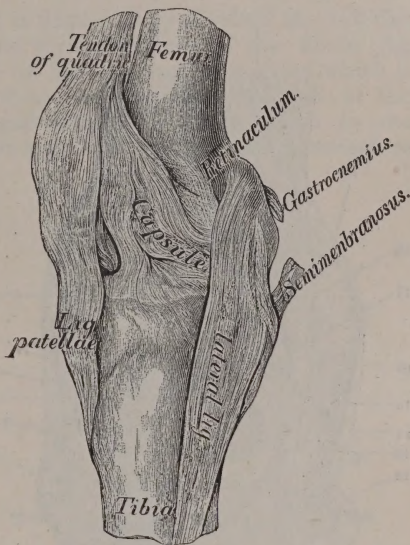


Fig. 278.—Inner side of right knee, 3. The word capsule is placed on the border of attachment of the fibres from the *vasti* into the capsular ligament.

The femoro-tibial joint is divided sagittally by the structures filling the intercondyloid notch into two lateral condylarthroses, which, however, are only partially separated. Vertically the knee consists of two joints separated by the interarticular semilunar cartilages—an upper or menisco-femoral, wherein the angular motion of flexion and extension takes place, and a lower or menisco-tibial, wherein a certain amount of rotation can take place. In man the synovial cavity is continuous throughout.

The **capsular ligament** which underlies the surrounding muscles consists of a thin fibrous layer, imperfect in front, weak in some places, thickened in others. It is supplemented by the attachment to it of accessory slips derived from the modified and adherent tendons and sheaths of neighbouring muscles. These form—A, the system of patellar ligaments; B, the lateral ligaments; C, the oblique posterior ligaments.

A. In front of the joint beneath the skin and fascia lata lies medially the

ligamentum patellæ (fig. 277), which consists of a strong flat band of fibres descending from the apex of the patella downwards, and a little outwards to the front of the tubercle of the tibia. This is, strictly speaking, the continued tendon of the *quadriceps* passing beyond the sesamoid bone to its insertion. The lateral fibres of the *vasti* which descend on either side of the patella, together with the sheath of the tendon and the fascia lata, form a thin imperfectly trilaminar layer on each side of the patella and its ligament, extending from the *quadriceps* above to the tibia below, merging laterally into the capsule, for the anterior sub-patellar deficiency in which these, together with the patella and its ligament, compensate.

Several strata of fibres can be separated in this lateral system of patellar ligaments to which special names have been given. These consist of—1st, vertical fibres descending from the *vasti*, especially from the *vastus internus*, which expand as they descend to be attached to the inner condyle of the tibia. Similar vertical fibres underlie and are attached to the ilio-tibial ligament on the outer side. Beneath these lies, 2nd, a layer of oblique fibres sometimes described as the *retinacula of the patella*; arising from the points of the epicondyles and inserted into the edges of the

Fig. 279.—Posterior surface of right knee, $\frac{1}{2}$. 2, Femur; 9, fibula; 10, popliteus; 11, 13, descending fascial insertion of semimembranosus (1); 14, internal lateral ligament; 15, tendon of semimembranosus 19, inner condyle; 12, anomalous exostosis.

patella, those on the inner side are the stronger and more distinct (fig. 278); still deeper is a third layer of fibres which decussate these, attached above to the femur beneath the edge of the quadriceps, to the deep surface of the quadriceps and side of the patella; these fibres descend diverging to the tibia, and form the continuation of the true capsule.

B. (1) **The internal lateral ligament** (fig. 278) is a strong flat band arising narrow from the inner epicondyle of the femur close to the front border of the insertion of the tendon of the *adductor magnus*, of which a portion of it was originally a continuation; its fibres diverge as they pass over the medial aspect of the joint, and many of them are at first inseparably united to the capsule, but it separates therefrom as it descends along the inner edge of the tibia to be attached to this edge of the shaft of that bone a little below the level of the tubercle. Its hinder border appears distinct below, where it bridges over the tendon of the *semimembranosus* from which it is separated by a bursa; still lower the inferior internal articular artery passes beneath it, and it then becomes inseparably attached to the fascial sheath of the *popliteus* muscle. It is crossed superficially by the tendons of *sartorius*, *gracilis*, and *semitendinosus*.

(2) **The external lateral ligament** is displayed by dividing the anterior part of the tendon of the *biceps* above the styloid process of the fibula (fig. 279, 4). It is a round cord surrounded by the biceps tendon, from which it is usually separated by a bursa, and continuous below into the origin of the *peroneus longus*, of which it is a dismemberment. It is attached to the external epicondyle, and passes downwards and backwards to the peroneal or anterior tubercle of the head of the fibula (*ib.*, 8), overlying the *popliteus* tendon (*ib.*, 6) and the inferior outer articular vessels.

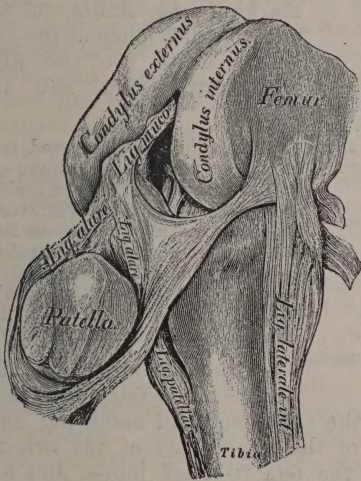


Fig. 280.—Right knee-joint opened showing the mucous and alar ligaments.

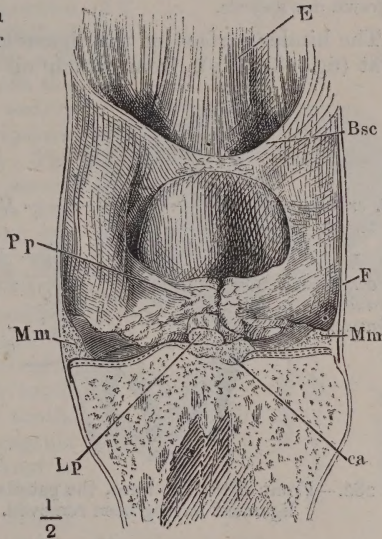


Fig. 281.—Knee opened from behind, the femur removed, showing the patella and its pouch—F, capsule; Bsc, semilunar cartilages; Lp, posterior crucial ligament; ca, spine of tibia. Note the thickness of the cartilage on the outer and inner tuberosities.

C. From the tendon of the *semimembranosus* (*ib.*, 1) immediately above its insertion a flat band (*ib.*, 17) ascends obliquely outwards across the back of the joint over the intercondyloid notch, and the back of the outer condyle, to become lost in the capsule above this last. This **ligamentum posticum** is posterior to, but inseparable from, the back of the capsule on which it exercises traction, drawing it backwards during flexion. It underlies the great popliteal vessels. The **capsule proper** can be seen in the intervals between these bands, to

the edges and deep surfaces of which it inseparably adheres. Posteriorly it is strong, and consists mostly of vertical fibres in several strata, separated by small masses of fat, underlying the ligamentum posticum (fig. 279). This descends from above the condyles and intercondyloid notch to the hinder edge of the tibial head. It is pierced by several canals for the azygous articular vessels and small pellets of fat, and it has undefined masses of adenoid tissue adherent to its hinder surface. On the upper and back part of the outer condyle (*ib.*, 3) the tendons of origin of the *external gastrocnemius* and *plantaris* are adherent to the capsule, and at their point of origin there is often a sesamoid cartilage or bone. From this there descends a strong, sometimes partially distinct vertical band of the capsule (**posterior external lateral ligament**), which is attached below by two slips, one arcuated which curves inwards to be lost in the capsule below the ligamentum posticum (*ib.*, 7, 5), and one direct attached to the sheath of the *popliteus* tendon and styloid process of the fibula (fig. 284). Above the internal condyle this capsule is perforated, and the bursa beneath the *internal head of the gastrocnemius* communicates thereby with the joint in 17 per cent. of limbs.

To display the internal structures in the knee-joint the *quadriceps* tendon should be divided above the patella, and the fascial expansion continued down therefrom should be divided downwards on each side to the front of the lateral ligaments. The patella is then to be drawn downwards.

The hinder surface of the ligamentum patellæ is covered by a large cushion of fat (fig. 281, Pp), from which on each side a crescentic fold of synovial membrane extends upwards along the edge of the patella, marking the limits of the anterior deficiency of the capsule. These are the **alar ligaments** (figs. 280 and 281).

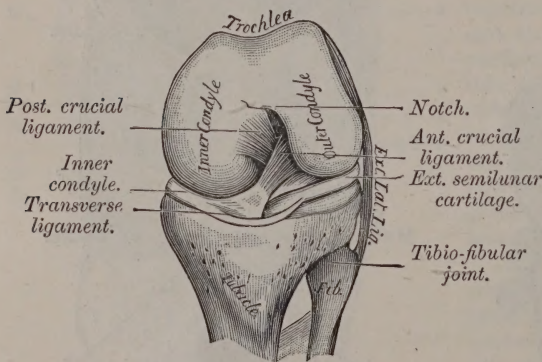


Fig. 282.—Front of the left knee, the patella and mucous ligament having been removed.

From the middle of the surface of the fatty mass there ascends a flattish weak band to the front of the intercondyloid notch (fig. 280). This **mucous ligament** is the last shred of the upper part of the original partition between the femoro-patellar and the femoro-tibial joints, and survives because of its use in regulating the position of the fatty mass in the different positions of the joint.

The mucous ligament is the remains of that part of the front of the capsule which was originally adherent to the femoral origin of the extensor of the toes. By it the sub-patellar cushion of fat is drawn upwards beneath the patella when the joint is flexed, while it is drawn forward by the ligamentum patellæ in extension.

On dissecting through the mass of fat a bursa is seen above the tubercle of the tibia under the ligamentum patellæ. This communicates with the knee in 8 per cent. of limbs. Farther backward the last shred of the lower part of the front of the true capsule is seen as a variable transverse band passing across

from the front border of one semilunar cartilage to the other, the **transverse ligament**, buried in the fat on the front of the head of the tibia.

By dividing the mucous ligament the **anterior crucial ligament** can be seen in the middle of the joint attached above to the back and inner part of the outer condyle, passing forwards and downwards to the tibia in front of the spine between the anterior cornua of the two semilunar cartilages. To see the **posterior crucial ligament** the posterior part of the capsule should be dissected away, whereupon it appears attached to the front and outer aspect of the inner condyle, descending nearly vertically to be inserted behind the spine of the tibia by two slips—one into the bone behind the posterior cornu of the internal semilunar cartilage, the other, **ligament of Wrisberg**, into the hinder edge of the external semilunar cartilage (fig. 284).

The crucial ligaments appear to cross each other whether viewed from the front, from the side, or from above. Being placed behind the axis of motion, they are made tense by extension, as are the lateral ligaments with which they co-operate in limiting rotation. The lateral ligaments check rotation outwards, but if they be divided from the femur, outward rotation can be performed freely. Rotation inward is checked by the crucials.

The **semilunar cartilages** are crescentic menisci, with thick, convex margins attached to the inside of the capsule of the knee, and thin, concave edges directed inwards towards the centre of the joint. The **external** is nearly circular in outline, the **inner** is semi-elliptical, with its long axis from before backwards. The front and hinder ends of each cartilage are purely fibrous and attached to the tibia before and behind the spine. The anterior cornu of the internal cartilage is attached in front of that of the external, from which it is separated by the attachment of the anterior crucial ligament. The posterior cornu of the internal is behind that of the external, and is generally divided into a weak band attached to the inner tooth of the spine, and a stronger to the outer tooth. The internal cartilage is fixed to the capsule along its entire convex margin; the external is crossed externally by the tendon of the *popliteus*, and the bursa surrounding that tendon communicates with the joint above and below the cartilage. On this account, and from the greater laxity of the part of the capsule attached to the outer cartilage, and from the close approximation of the cornua of this cartilage, the outer is more freely movable on the tibia than the inner.

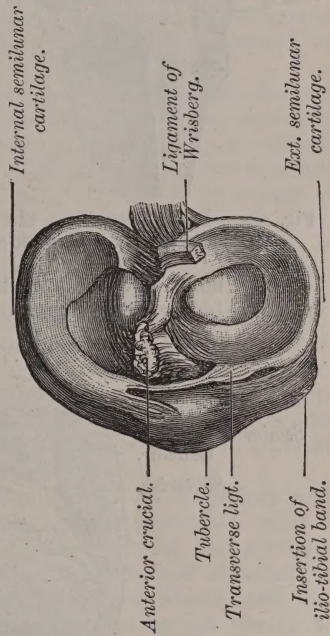


Fig. 283.—Semilunar cartilages of left knee.

The attachment of the convex border of the semilunar cartilage to the tibia is sometimes called the **coronary ligament**, but it is nothing more than a portion of the capsule artificially separated from the rest in opening the joint. To understand the proper relation of the semilunar cartilages to the femur, it is advisable, having dissected one knee-joint in the ordinary way, to divide the capsule of another between the inferior edge of the semilunar cartilages and the edge of the tibia, to detach the crucial ligaments and the cornua of the semilunar cartilages from the tibial spine, and thereby to leave the cartilages attached to the femur. It will be seen that the superior coronary attachment of the cartilages, *i.e.*, the portion of capsule between their margin and the femoral condyle, is really as strong, though looser than the inferior.

The outer cartilage is grooved by the *popliteus* tendon, the hole whereby the menisco-tibial joint communicates with its bursa has two crescentic borders, the outer of which is connected to the edge of the posterior external lateral ligament, and through it to the styloid process of the fibula. The upper opening, or that into the menisco-femoral joint, has a strong band of the capsule along its anterior border.

In the motions of the knee the patella glides over the trochlea femoris, the portion of the patella and of the femur in contact varying at each angle of flexion.

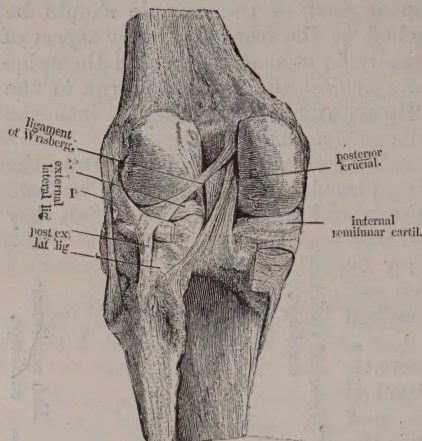


Fig. 284.—Back of left knee, the posterior ligament having been removed.

but shifts backwards in flexion; and while the direction of the axis inclines backwards and inwards in the extreme of flexion, it inclines backwards and outwards in extreme extension, the two axes intersecting each other at an angle of 18° . In this motion also the tibia itself rotates through a small arc on a vertical axis traversing its head; hence both bones glide on each other, and there is no one spot of either

always in contact with the neighbouring bone. On account of the shift in the axis, extreme extension is associated with rotation outwards of the foot, and extreme flexion with

Gastrocnemius inner head

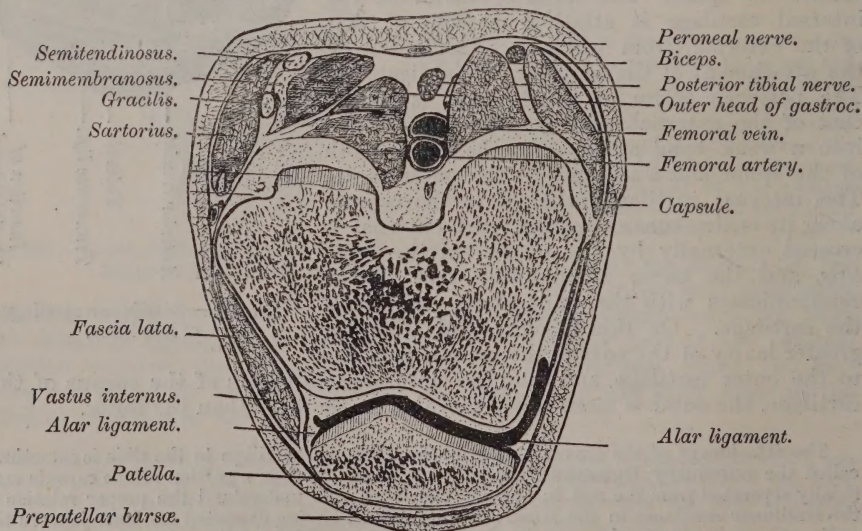


Fig. 285.—Horizontal section through femoral condyles.

a very slight rotation inwards. The change from the outward rotation takes place during the first quarter of the act of flexion, while the knee is

moving from 0° to 45° . Extreme flexion can be carried through 135° . The shifting of the axis is due to the different extent and form of curvature of the two condyles, and has been aptly compared to the rotation of the forewheels of a carriage in turning a corner, the inner condyle constituting the fixed wheel and the outer that which rotates around it.

The line of gravity passes in front of the axis of motion in the joint, hence, when the body stands upright its weight suffices to keep the joint extended, and the quadriceps and ligamentum patellæ are lax.

The attachment of the posterior crucial ligament, which is the strongest of the intrinsic ligaments of the knee, is the determining factor of the rotation in extension. When the rapidly-widening spiral of the condyles is forced into the sockets, and the bands between the femur and the tibia are stretched, this ligament draws the point of insertion and the external semilunar cartilage backwards and inwards, and the weight of the body retains them in that position, so locking the joint. By this rotation also the ilio-tibial ligament is made tense. Flexion must consequently commence by a slight rotation inwards of the tibia, relaxing this ligament, and that is performed by the *sartorius*, *gracilis*, and *semitendinosus*, which trio are thus associated to unlock the fixity of the joint.

The knee may be regarded as a pair of twin condylarthroses, and the two are nearly separated from each other; posteriorly the capsule and the posterior crucial are united, while between the two crucials there is sometimes a variable narrow slit near their femoral ends, and the space in front between the anterior crucial and the mucous ligament is occasionally partially closed by a fold of synovial membrane.

In comparing the knee and elbow it is to be remembered that the knee is equivalent to a humero-radial joint only, with no part representing the humero-ulnar joint.

113. TIBIO-FIBULAR JOINTS.—The bones of the leg are united together by a plane joint above and by a synarthrodial joint intermediately and below. These unions permit of very trifling motions, the maximum displacement permitted at the upper end being a very slight sliding of one surface on the other, and at the lower end a very slight upward thrust, varying in amount in different individuals. No rotation can occur in either joint.

The **superior tibio-fibular joint** is surrounded by an imperfect and unequal capsular ligament, attached around the articular margins, with a strengthened anterior band of transverse fibres under cover of the *peroneus longus* and *extensor digitorum* and a weaker posterior beneath and attached to the outer head of *soleus*. The capsule is usually deficient above, and the popliteal bursa communicates with the joint, thereby uniting its cavity to that of the knee. Below the articulation is an **oblique peroneo-tibial band** descending from the fibula to the tibia.

The **interosseous ligament**, like that in the forearm, is a membrane which unites the outer edge of the tibia with the antero-internal edge of the fibula. It is separated above from the upper tibio-fibular joint by an interspace containing fat and traversed by the anterior tibial vessels. The fibres principally descend from tibia to fibula, but a few upper oblique fibres run the other way; from its front surface arise the *tibialis anticus* and *extensor proprius hallucis* while on it lies the anterior tibial artery; posteriorly it gives insertion to the *popliteus* and origin to the *tibialis posticus*. Below, the membrane divides into several layers separated by masses of fat, but it terminates about 1 cm. above the ankle.

The **lower tibio-fibular joint** is closely connected with the ankle-joint. From the latter a pouch of the synovial cavity insinuates itself for about

5 mm. between the opposed surfaces of the bones, which are here tied together by two ligaments, anterior and posterior. The anterior is a flat band passing obliquely from bone to bone in front. The posterior is very strong, attached not only to the hinder surfaces of the contiguous bones, but also to the opposed edges of the external malleolus and outer and hinder margin of the tibial articular facet. Its anterior surface forms a hinder lip for the ankle-joint after the manner of glenoid ligaments, though differing in development from a true glenoid lip.

Above the pouch of synovial membrane continued up from the ankle, there

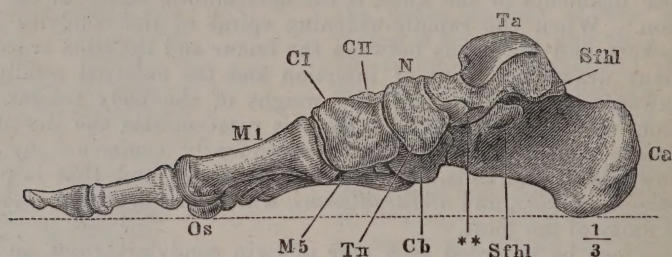


Fig. 286.—Bones of the right foot, seen from the inner side.

is a small gap corresponding to the upper parts of the opposed triangular surfaces of the bones, the tibial side of which is covered by periosteum, the fibular by a fat holding membrane.

114. THE BONES OF THE FOOT in general arrangement correspond to those of the hand, differing in being modified for firmness, not mobility. The tarsus or first segment exceeds the metatarsus in length, and this the phalanges. The foot is placed in a condition of permanent pronation and over extension, and has its plantar surface turned downwards, its dorsal upwards.

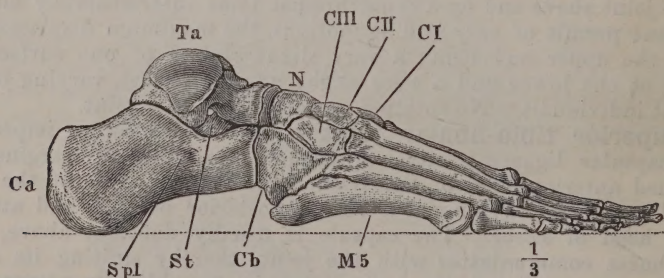


Fig. 287.—Bones of the right foot, seen from the outer side.

The tarsal bones are grouped in three rows—a basal, consisting of the astragalus and calcaneum; a central or navicular; and a distal row consisting of the cuboid and three cuneiforms.

Astragalus (figs. 286, Ta; 289) presents the following parts:—(1) An upper quadrate articular surface for the tibia, concave transversely, convex sagittally; wider in front than behind (1:·8). In the living limb the plane of this surface is horizontal. (2) An ear-shaped facet for the internal malleolus on the inner side. (3) A triangular, vertically concave facet for the fibula on the outer side. (4) An elongated ovoid convex facet in front, forming the **head of the astragalus** to articulate with the hinder concavity of the navicular. (5) A narrow convex facet below and in front, continuous with the last, for the anterior facet of the calcaneum. (6) A large concave facet on

the posterior part of the inferior surface for the hinder facet of the calcaneum. It thus exhibits six facets which articulate with four bones. The posterior non-articular area of the bone is elongated backwards into a **processus posterior**, which consists of three parts—(7) a sulcus in the hinder thin edge for the tendon of the *flexor hallucis longus*; (8) a prominent **outer posterior tubercle**, external to this, for the posterior peroneo-astragalar ligament. This is occasionally a separate ossicle, the **os trigonum**. (9) A rounder and less prominent **inner posterior tubercle**. (10) The inner surface is rough and irregularly hollowed for ligaments between surfaces 2, 4, and 7, whose front and hind portions are convex for ligaments from the fibula. (11) A rough upper neck surface for the anterior ligament of the ankle between 1 and 4, usually bearing a boss, which limits the forward flexion of the ankle-joint. (12) A deep interosseous sulcus on its under surface between surfaces 5 and 6 passing from behind forwards and outwards, and widening in front, giving attachment to interosseous ligaments which tie it to the calcaneum.

The astragalus is the only bone of the tarsus which directly touches the leg bones, and its long axis is directed forwards and inwards. It consists of a body

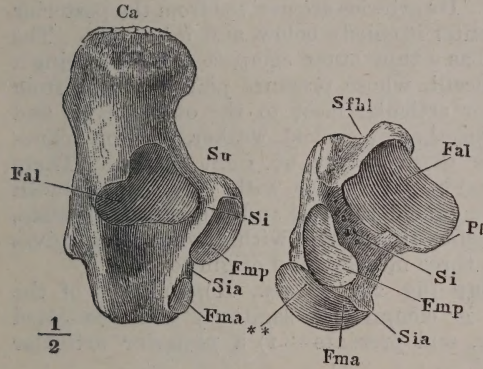


Fig. 288.—Calcaneum seen from above, right side.

Fig. 289.—Astragalus seen from below, right side.

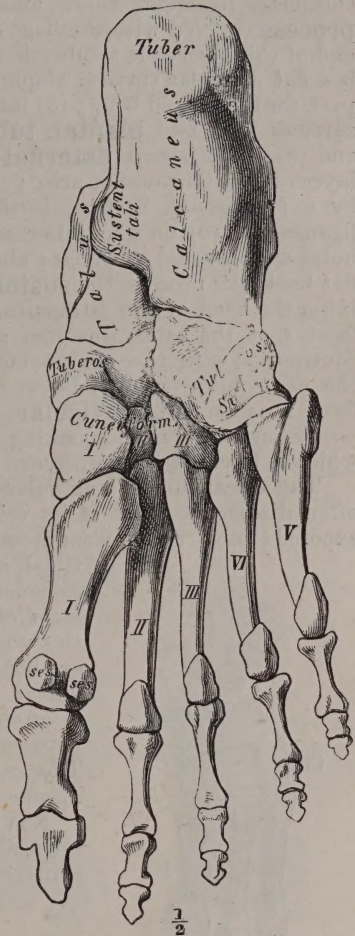


Fig. 290.—Bones of right foot, plantar surface.

behind and a convex head in front. The curve of its upper surface differs a little along its inner and outer edge. In a detached astragalus the outer edge appears higher than the inner, but during life the two are on the same plane, as the obliquity is really in its lower surface. The astragalus is a very vascular bone, and is nourished by branches of the tarsal artery. It gives attachment to no muscles.

Calcaneum, Os Fibulare, the largest and hindmost of the tarsal bones, which forms the skeleton of the heel, is placed below the astragalus, and has its long axis directed forwards and a little outwards. It presents—(1) a posterior projecting **tuber calcanei** or heel process (fig. 288, Ca), whose hinder surface is smooth above and covered by a bursa, rough and vertically striated

below for the insertion of the *tendo Achillis*, and pierced by calcanean branches of the posterior tibial artery; (2) a convex articular surface above, for the astragalus; (3) between 1 and 2 on the upper surface is a rough convex area, covered with fat during life; (4) the outer surface appears as a vertical flat surface, marked below 3 by an external tubercle for the peroneo-calcanean ligament, below and in front of which is often (5) a **trochlear process** covered with cartilage for the *peronei* tendons; (6) above the anterior end of this surface is a tubercle for the *extensor digitorum brevis*; (7) anteriorly is a flat articular surface, sloping a little backwards and inwards at its lower part, for the cuboid bone; (8) inferiorly and behind, where the hinder and lower surfaces join, two **plantar tubercles** project downwards, a large **internal**, and a small sharp **external**; from these the plantar fascia and first layer of plantar muscles arise; (9) in front of these, and separated from them by a long rough surface, is the **cuboid tubercle** for the calcaneo-cuboid ligament; (10) on the inner side the bone is concave, pierced by vascular holes and covered with fat; above, this surface is prolonged forwards into a flat hook-like process, the **sustentaculum tali**, projecting inwards and underlying the head of the astragalus, its upper surface bearing the concave facet for facet 5 of the astragalus (fig. 289, Fmp); its inferior surface is grooved, in continuity with the groove marked 7 on the astragalus, for the tendon of the *flexor hallucis*. (12) Between the articular facet on the sustentaculum and facet 2 is an **interarticular sulcus** (fig. 288, Si), corresponding to that on the astragalus, and making when the bones are apposed a **sinus tarsi** which is filled with interosseous ligaments.

The calcaneum is a vascular bone, and much exposed to injury; hence it is often diseased. Most of its veins escape at the outer side, and are therefore exposed to obstruction from pressure. Its arteries are derived from the posterior tibial, and enter it chiefly below and internally. The calcaneum has a thin outer compact layer covering a mass of cancelli, whose pressure planes radiate from the posterior articular facet to the outer layer, and are bound together by curved, weaker, traction planes which cross these nearly at right angles. There is often a cavity or a space with very weak cancelli between the cuboid tubercle and the anterior surface. The calcaneum articulates with two bones, gives insertion to three muscles, and origin to five.

Navicular (fig. 286, *et seq.*, N), in front of the astragalus, is compressed sagittally and elongated transversely, and presents—(1) a posterior articular

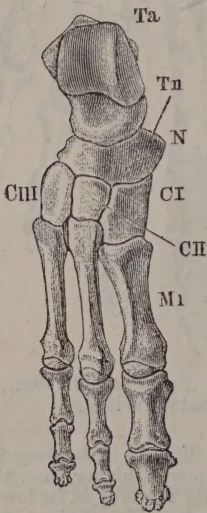


Fig. 291.—Inner series of bones of foot, seen from above—Ta, astragalus; N, navicular; CI, internal cuneiform; CII, middle cuneiform; CIII, external cuneiform.

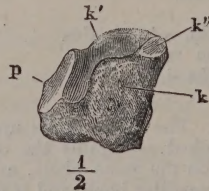


Fig. 292.—Internal cuneiform bone, seen from its outer side—k', facet for middle cuneiform; k'', facet for second metatarsal; p, facet for navicular.

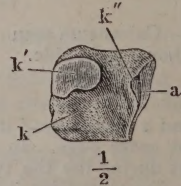


Fig. 293.—External cuneiform, seen from its inner side—k', facet for outer side of second metatarsal; a, anterior facet for third metatarsal; k, surface for interosseous ligaments.

concavity for the head of the astragalus; (2) a superior rough surface, narrow and flat from before backwards, but convex from side to side, elongated internally and below, into (3) the **navicular tubercle** (fig. 291, Tn), which is palpable in the living foot in front of and below the inner ankle. (4) The anterior or distal surface of the bone is convex, and marked by three triangular surfaces, an inner with the base below for the inner cuneiform, a middle and an outer with their bases above for the middle and outer cuneiforms respectively; (5) externally the bone has a rough narrow end with an inconstant facet for the cuboid. (6) On the lower surface, the tubercle projects, giving insertion to the *tibialis posticus*, external to which the bone is rough and knobby for deep ligaments (fig. 290, *Tuberos*). This bone articulates with four bones always, occasionally with five, gives insertion to one muscle, and origin to none. Its strongest cancelli run sagittally.

Internal Cuneiform or Tarsale I.—This bone is a wedge with a rounded base below, a kidney-shaped anterior and a smaller, triangular, concave hinder articular surface, the former for metatarsal I., the latter for the navicular. Externally it has an articular facet along its hinder and upper margin like a reversed L, in front of which is an area for interosseous ligaments and, still farther forward, a facet, near its dorsal border, for metatarsal II. Its inner side is grooved from above downwards and forwards for the tendon of the *tibialis anticus*, and its plantar base is rounded and rough, giving attachment to ligaments, to a slip of *tibialis posticus*, and to the *flexor brevis hallucis*. This bone articulates with four bones, gives origin to one muscle, and insertion to two (fig. 292).

Middle Cuneiform or Tarsale II.—The smallest bone of the tarsus, a wedge with a square-cut flat base directed upwards, and a sharp edge directed towards the sole. Its proximal end is a little the wider, and articulates with the navicular, while the distal has a triangular facet for metatarsal II. Internally it has a reversed L-shaped facet along its hinder and upper border for the inner cuneiform bone, while externally it has a vertical somewhat bilobed facet along its hinder border for the outer cuneiform. It articulates with four bones, gives partial origin to one muscle, but insertion to none.

External Cuneiform or Tarsale III. is larger and wedge-shaped, with flat dorsal base and plantar apex. Like the middle, it has a triangular facet behind for the navicular, and one anteriorly for metacarpal III., both of which are cut somewhat obliquely, so that they form acute angles, the anterior one with the inner side of the bone, the hinder with the outer side. Like the

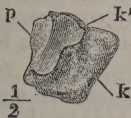


Fig. 294.—Right middle cuneiform bone, external surface—p, facet for navicular; k', facet for external cuneiform; k, rough space for interosseous ligaments.

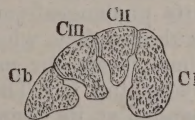


Fig. 295.—Transverse section across the cuneiform and cuboid bones.



Fig. 296.—Right cuboid bone, front view.

middle it has also two lateral facets along the posterior margin of each lateral surface for the cuboid and the middle cuneiform respectively, but it differs from the middle in size, in having a convex outer and concave inner surface, and in having also two very small marginal facets along its distal borders for metatarsals II. and IV. It thus articulates with six bones, gives origin to one muscle, and insertion to a slip of the *tibialis posticus*.

The **Cuboid** made up of the combined fourth and fifth tarsals, is an irregularly cubical bone in front of the calcaneum, and bears anteriorly two articular surfaces for metatarsals IV. and V. (fig. 295). The anterior and posterior sur-

faces converge externally, so that the outer non-articular margin is short. Internally it presents a facet for the external cuneiform, reaching the dorsal surface; in front and behind this are areas for ligaments: sometimes a second facet for the navicular is on its hinder and inner margin. The upper surface is rough and plane, the lower is crossed by a prominent rough ridge, the **cuboid tuberosity**, for the calcaneo-cuboid ligament, in front of which is a deep groove directed obliquely forward for the *peroneus longus*. It articulates with four, often with five bones, gives insertion to a slip of the *tibialis posticus*, and gives origin to two muscles, the *flexor* and *oblique adductor* of the hallux.

The line of junction of the astragalus and calcaneum behind, with the navicular and cuboid in front, is sometimes taken advantage of in partial amputation of the foot, and is known as *Chopart's line*. It will be observed that there is a posterior calcanean process of the cuboid, which undershoots the calcaneum, and so supports its front border.

Development.—Each tarsal bone ossifies from a single centre. That of the calcaneum appears in the sixth month of fetal life; that of the astragalus in the seventh; that of the cuboid at birth; the external cuneiform in the first year; the internal in the third; and the middle in the fourth; the navicular in the fifth. An epiphysial crust forms for the calcaneum posteriorly in the tenth year, and consolidates at sixteen.

The tuberosity of the calcaneum represents the pisiform bone in the hand, being the remains of a sixth digit; it is fused with the germ of the fibulare, which forms the body of the calcaneum. The astragalus is the representative of the rest of the first row of the carpus, and is essentially a tibiale, into which a small prehalluceal strip of cartilage, which existed on the inner side of the tarsus in the second month, has become worked up. This portion which gives rise to the outer tubercle of the posterior process may remain isolated, and become separately ossified as the *os trigonum*, which thus represents the *inter-medium*. The navicular represents the centrale. The cuboid represents the unciform; and the three cuneiforms, respectively, the trapezium, trapezoid, and magnum.

The **metatarsals** are five and form a closely united row, whose proximal ends gradually slope backwards, so that a transverse line continued across from the first tarso-metatarsal joint cuts the shaft of the fifth at its posterior two-fifths, and the plane of the head of the fifth similarly divides the first at its anterior two-fifths. Each has a squarely cut proximal end with flat articular surfaces, a shaft which is somewhat triangular but with no triangular dorsal flat surface, and which tapers to its phalangeal end, and a laterally compressed, vertically elongated, distal articular surface, which is twice as long as it is broad. Each has two lateral proximal facets for mutual articulation, and a rough pit for ligaments immediately behind it. The **first** is exceptional in character, it is thick and strong, expanded at its distal end, having a kidney-shaped proximal articular facet convex inwards, with a strongly marked plantar tuberosity, which is rough and hollowed laterally for the insertion of the tendon of the *peroneus longus*, ridged medially for the *tibialis anticus*. The shaft is very concave below. The distal head is large, with a rounded, laterally compressed articular surface, marked by two large plantar facets for the articulations of the sesamoid bones.

The **second metatarsal** is the longest, its proximal end occupying a mortice space between the external and internal cuneiforms; it has consequently on its base not only a terminal facet for the middle cuneiform but two lateral facets on each side; it has facets for the internal cuneiform, and occasionally for the first metatarsal on the inside, and for the external cuneiform and third metatarsal on the outside. The facet for the third usually consists of two separate rounded surfaces, a dorsal and a plantar.

The **third metatarsal** is a little shorter and is marked by an obliquely cut base, whose acute angle is external. Its proximal end has two lateral facets on the inside, one dorsal and one plantar for the second metatarsal, and on the outside a single longer facet for the fourth. The **fourth metatarsal** has also an oblique base, with a single lateral facet on its outside, and two on the inside, one very small and marginal for the external cuneiform, and a second larger for the third metatarsal. The ligamentous pit on its outer side is very deep.

The **fifth** has a transversely elongated facet for the cuboid, a long, rough tuberosity projecting outwards, palpable through the soft parts, and a very small phalangeal head.

Development.—Each metatarsal develops by means of a shaft-centre, which appears in the ninth week. In addition, the first metatarsal has an epiphysis at its proximal end appearing in the third year, and consolidating at twenty. The other metatarsals have distal, not proximal, epiphyses, which appear at different periods from five to eight years of age, and consolidate at twenty-one. The nutrient artery runs towards the toe in the first, towards the ankle in the others.

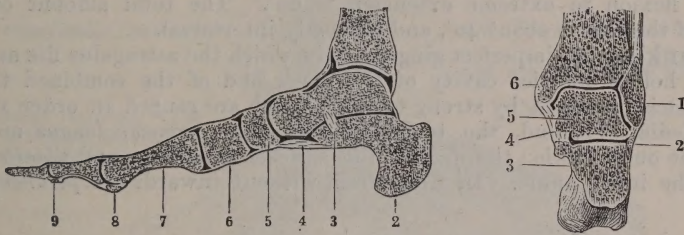


Fig. 297.—Sagittal and coronal vertical sections through the ankle-joint, showing the relations of the cancelli and of the synovial membranes.

The first metatarsal articulates with four bones, the second with five, the third with four, the fourth with four, and the fifth with three. The first gives insertion to one muscle and origin to one, the second gives origin to three, the third to five, the fourth to five, and the fifth gives insertion to two and origin to five.

The **phalanges** in the foot are fourteen, as in the hand, but each bone is shorter. The **proximal phalanges** have narrow, laterally compressed shafts, dilated proximal ends, marked with strong lateral tubercles and trochlear distal ends. That of the first is the largest, and the others follow in numerical order. The bases also diminish in depth from within outwards. That of the first is more than treble the bulk of any of the others.

The **medial phalanges** are short, with a trochlear hollow at the proximal, a trochlear convexity at the distal end. The shafts diminish in size rapidly from within outwards, that of the fifth being an irregular flattened cube. The **ungual phalanges** have trochlear bases and short, broad, semicircular unguis processes; that of the first is the largest, then that of the third, second, fourth and fifth successively. The second and third phalanges of the little toe usually ankylose in the adult.

The foot is narrowest at the heel, widens to the heads of the metatarsal bones, and its bones form an antero-posterior arch with a single pier behind (the calcaneum), and a double pier in front, one at the distal end of the first metatarsal internally, the other at the tuberosity of the fifth metatarsal externally. The weight of the body comes on the interval between the first and second of these. The foot may be longitudinally divided into two parts (fig. 291), the astragalus bears anteriorly the navicular, cuneiforms, and the three inner toes;

the calcaneum bears the cuboid and the two outer; the inner side of the foot is the more actively functional in weight-bearing; the outer is essentially retrogressive, and shows many signs of degeneration of its separate elements.

The antero-posterior arch is kept up by the strong plantar ligaments, and by the obliquities of the articular surfaces of the bones. There is a transverse arch (fig. 295) with its two piers at the cuboid and fifth metatarsal externally, and at the internal cuneiform and first metatarsal internally. This is produced by the wedge-shapes of the cuneiform bones and heads of the metatarsals.

115. JOINTS OF THE FOOT.—The articulations of the foot are firmer and less movable than those of the hand, and the ligaments have a tendency to become fasciculated and to run into cords, while those of the hand tend to diffuse themselves into expansions. In rest the foot is in a position of over-extension, and the condition which is called *flexion* of the ankle corresponds to the extreme of *extension* in the wrist, while the foot cannot be brought into the right line with the leg. Abduction and adduction as well as rotation can take place in the joint between the astragalus above and the calcaneum and navicular below more freely than in the ankle proper. The range from extreme flexion to extreme extension is 60° . The total amount of lateral motion of the foot is about 40° , and is mostly intertarsal.

The **ankle** is an imperfect ginglymus in which the astragalus fits as a tenon into the hollow mortice cavity of the lower end of the combined tibia and fibula. It is protected by strong tendons which are ranged in order round it, viz.:—Medially behind, the tendo Achillis; the *peroneus longus* and *brevis* behind the outer ankle; the *flexor hallucis*, *flexor digitorum*, and *tibialis posticus* behind the inner ankle. In front from without inwards are *peroneus tertius*,

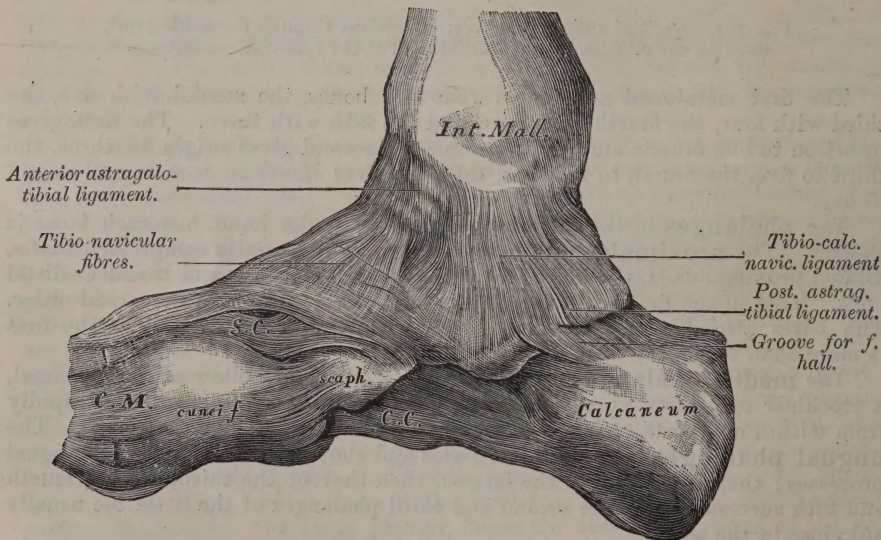


Fig. 298.—Inner side of the right ankle-joint, $\frac{3}{4}$

extensor digitorum, *extensor hallucis*, and *tibialis anticus*. It is also surrounded by an imperfect capsular ligament attached above to the front and back edges of the articular surface of the tibia, below to the astragalus around its upper articular surfaces. Posteriorly it is weak and inseparable from the synovial membrane;

anteriorly it is strengthened by a few oblique fibres, and is separated from the synovial membrane by a mass of fat; on the former surface it is transversely folded in extension, on the latter in flexion. The oblique anterior fibres pass from the supra-articular ridge of the tibia and front of the internal malleolus to the front and outer part of the neck of the astragalus. They are sometimes separated from the rest of the capsule under the name *anterior ligament*.

The inner side of the capsule is strengthened into a special fasciculated **internal lateral ligament**, a flat triangular band which extends from the notched lower edge of the inner malleolus to the inner side of the astragalus, sustentaculum tali, inferior calcaneo-navicular ligament, and the navicular bone; with a little dissection this can be separated into four parts, a *tibio-calcaneo-navicular* slip, an *anterior astragalo-tibial*, a *posterior astragalo-tibial*, and a *calcaneo-tibial* slip, but these are only differentiated bands of this portion of the capsule. On the outer side the capsule has become completely specialised into three separate cords, an **anterior astragalo-fibular ligament** from the

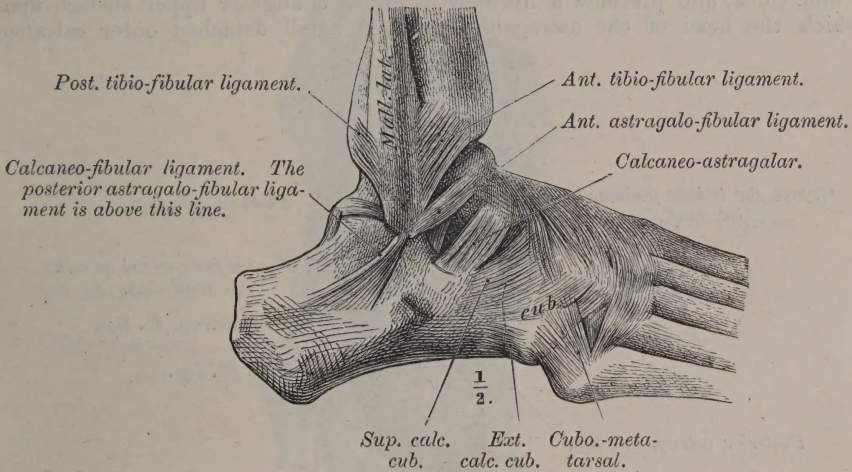


Fig. 299.—Outer side of the ankle-joint.

front of the fibula to the outer part of the neck of the astragalus, a middle or **calcaneo-fibular ligament** passing to the calcaneum from the lower end of the fibula, and an ascending fasciculated **posterior astragalo-fibular** from the back of the groove in the fibula to the outer posterior tubercle of the astragalus.

When the ankle is flexed the wide part of the astragalus is driven between the two malleoli, raising the outer a little, and stretching the interosseous ligaments; when extended, the narrower end lies between the malleoli, and in that position a little lateral motion is possible.

In extreme flexion the middle articular process of the tibia fits into a fossa on the dorsal surface of the neck of the astragalus, and further motion in this direction is limited by the prominent boss which borders that fossa in front.

The astragalus forms two joints with the other tarsal bones, one the posterior astragalo-calcanean, the second an astragalo-calcaneo-navicular. These are the most important of the intertarsal joints. The first of these is surrounded by a **capsule**, which is split up into several distinct slips, in the intervals between which the synovial membrane has but a weak fibrous investment; behind, it forms a thin **posterior astragalo-calcanean ligament**, often bifid, from the posterior external tubercle of the astragalus, to the upper and inner surface of

the calcaneum. Anteriorly, the capsule of this and of the anterior astragalo-calcanean articulations are united and form the thick, strong **interosseous ligaments** filling up the largest part of the sinus tarsi. These consist of two imperfectly separate layers of fibres, one belonging to the posterior, the other to the anterior astragalo-calcanean joint. Externally the capsule is deficient under the calcaneo-fibular and astragalo-fibular ligaments; but at the external mouth of the sinus tarsi there is an *external astragalo-calcanean ligament* from the upper and anterior tubercle of the calcaneum to the ridge on the outside of the neck of the astragalus. Internally it forms an **internal calcaneo-astragalar band** from the posterior internal tubercle of the astragalus to the back of the sustentaculum.

The head of the astragalus lies anteriorly in a socket formed by the navicular bone, the anterior concave facet on the sustentaculum tali, and the calcaneo-navicular ligament which unites the anterior edge of the sustentaculum tali with the inner and lower border of the scaphoid. This ligament is nearly 6 mm. thick, and presents a fibro-cartilaginous triangular upper surface upon which the head of the astragalus rests. A small detached outer calcaneo-

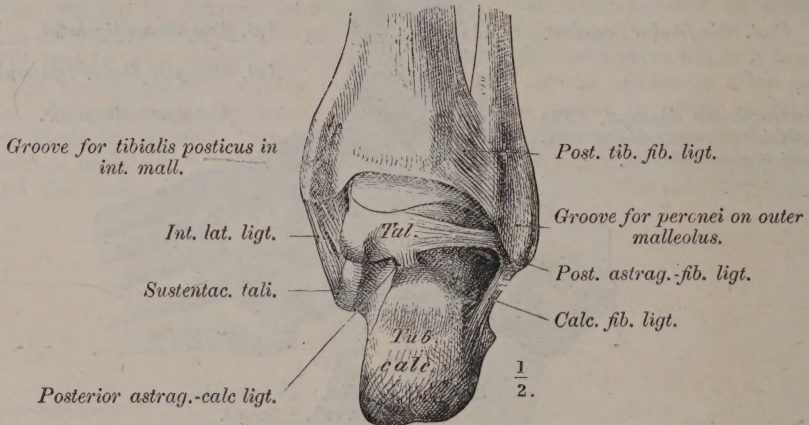


Fig. 300.—Posterior ligaments of the ankle.

navicular slip on the plantar aspect close to the cuboid completes the boundary of the socket.

This joint is protected by an imperfect and subdivided **capsule**, whereof the dorsal surface consists of two sets of decussating fibres arising together from the upper ridge on the neck of the astragalus, whereof the outer half pass inwards and the inner set pass outwards to be attached over the navicular, extending as far as the middle cuneiform. These are supplemented internally by the continued anterior fibres of the internal lateral ligament of the ankle, from which they are inseparable. Posteriorly the back of the capsule of this joint forms, with the anterior part of the astragalo-calcanean capsule, the **interosseous ligament** before mentioned.

The other intertarsal joints are plane joints whose capsules have been reduced to flat bands.

The **calcaneo-cuboid** joint and the most of the intertarsal joints are protected below by a great fibrous plantar mass, **ligamentum longum plantæ**, arising from the whole rough under surface of the calcaneum and its tubercles. This divides distally into lamellæ, of which the longest is the most superficial, and is inserted into the bases of the outer metatarsals, giving origin to some of the muscles of the sole, especially the *adductor hallucis obliquus*. This layer

sheathes the tendon of the *peroneus longus*. The second or deeper layer is attached to the cuboid tuberosity, along which it expands, and the third or deepest layer passes forwards and inwards to the inner border of the cuboid, internal to and behind the tuberosity.

In front of this and under its superficial layer is the **anterior transverse tarso-metatarsal ligament**, which consists of an internal and external part; the former arises from the internal cuneiform bone above the tendon of the *peroneus longus*, and, passing over the head of the second metatarsal, is inserted into the third and fourth metatarsals. The outer arises from the apex of the outer cuneiform, and passes into the tuberosity of the fifth metatarsal. A **posterior transverse intertarsal** joins the cuboid and navicular below.

The **calcaneo-cuboid joint** is protected by an imperfect and fasciculated capsule, of which there are around the articulation the following strengthened bands, two or three **dorsal calcaneo-cuboid**, the strongest of which is

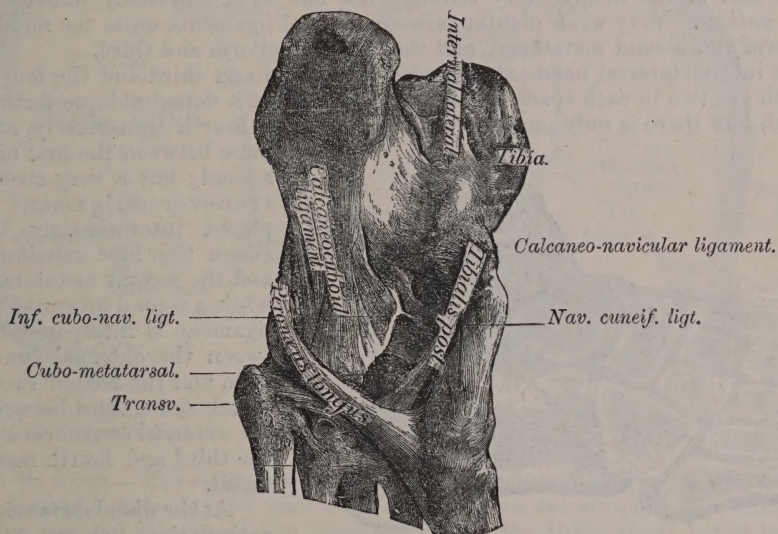


Fig. 301.—Superficial plantar ligaments.

external; below, the deep calcaneo-cuboid constitutes a part of the capsule. Internally there are two strata of **naviculo-cuboid ligaments**. These often surround and isolate a separate synovial membrane.

The **naviculo-cuneiform joint** consists of the union of the navicular behind with the three cuneiforms in front, and is inclosed in a single capsule; its synovial cavity extends forwards between the cuneiforms, as well as between the outer cuneiform and the cuboid, while a little pouch of it often projects backwards between the cuboid and the navicular. Dorsally the capsule is split up into five slips which arise from the navicular, one to the outer cuneiform, two bands, outer and inner, to the middle cuneiform, and two, outer and inner, to the inner cuneiform. On the plantar side the ligament is still more irregularly fasciculated, and inseparable from the tendon of the *tibialis posticus*, as it passes from the navicular to the three cuneiforms, especially the internal.

The union of the bones of the distal row among themselves is by means of short transverse ligaments in three series; on the dorsal surface there are dorsal ligaments generally arranged in paired proximal and distal slips

between the respective bones; two such slips tie together the cuboid and the outer cuneiform; several slips unite the outer and middle cuneiforms, and two unite the middle and internal.

Interosseous ligaments bind together the contiguous surfaces of the cuboid and outer cuneiform, the outer and middle, and the middle and internal, the last set being double, anterior and posterior. On the plantar surface are three similar sets of transverse fibres.

The tarsals and metatarsals are tied together by short sagittally placed slips, which, however, do not form regular capsules except for the first and fifth, for each of which there is an imperfect capsule attached by their proximal margins respectively to the inner cuneiform and cuboid bones. To the proximal end of the second metatarsal three bands converge dorsally, one from each cuneiform bone; three similar bands pass to the third metatarsal, and one passes to the fourth. The capsule of the fifth joint is a little stronger above than below; that of the first is very strong below but weak internally under the *tibialis anticus*. Very weak plantar tarso-metatarsal ligaments unite the middle cuneiform and second metatarsal, and the outer cuneiform and third.

The intermetatarsal ligaments between the second and third and the fourth and fifth are two in each space, a dorsal transverse and a dorsal oblique farther forward, but there is only one between the third and fourth transversely, and

none between the first and second; but a very strong transverse ligament is placed interosseously between the first cuneiform and the second metatarsal, while a second interosseous ligament is interposed between the external cuneiform and the second metatarsal, and a third between the external cuneiform and the third and fourth metatarsal.



Fig. 302.—Synovial membrane in ankle and intertarsal joints—*a*, tibia; *b*, astragalus; *c*, head of astragalus; *d*, posterior articular surface of calcaneum; *e*, tuber calcanei; *f*, anterior articular surface; *g*, navicular; *h*, cuboid; *i*, *k*, *l*, cuneiform bones; *m*, *n*, *o*, *p*, *q*, metatarsals.

At the distal metatarsal articulations there is a transverse ligament differing from that in the hand, as it involves the great toe as well as the others.

The **metatarso-phalangeal joints** resemble those of the fingers. The lateral ligaments and the two glenoid plates are very strong, and each joint has a greater dorsal extension than in the fingers. The surfaces are incongruous, and there is a convergence of the digits during flexion.

The two long ligaments of the sole, calcaneo-navicular and calcaneo-cuboid, bear the whole weight of the body in standing. The weight is borne anteriorly on the heads of the metatarsal bones, not on the toes.

The transverse and interosseous ligaments keep up the transverse arch, thereby guarding the vessels and nerves from pressure.

The line between the tarsus and metatarsus, along which a partial amputation of the foot is sometimes performed, is known as *Hey's line*.

There are usually six synovial membranes related to the tarsal bones, one in the ankle-joint, a second for the hinder astragalo-calcanean joint, a third in the astragalo-navicular, but this may communicate with the ankle, a fourth for

the naviculo-cuneiform extending between these bones to the three inner tarso-metatarsal joints, and usually into the naviculo-cuboid, a fifth between the cuboid and the two outer metatarsals, a sixth exists for the calcaneo-cuboid joint, and a seventh occasionally separates the first metatarsal from the internal cuneiform bone.

116. THE SKULL consists of the hard parts of the foremost united metamerer which constitute the head, and it forms a case for the protection of the brain, sense-organs, and the commencement of the digestive canal. It is made up of two parts, the **brain case** placed above and behind, and the **face** below

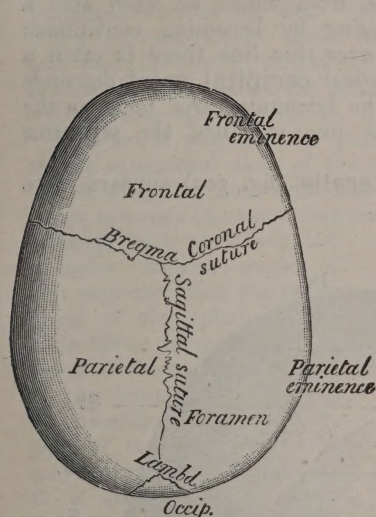


Fig. 303.—Skull seen in norma verticalis, $\frac{1}{3}$.

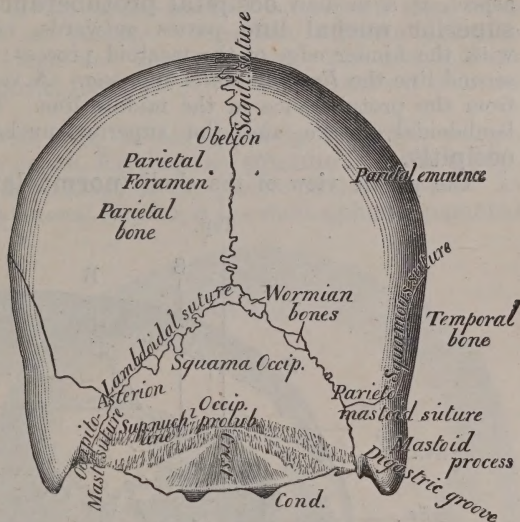


Fig. 304.—Norma occipitalis, $\frac{1}{3}$.

and in front. The eight bones of the former and thirteen bones of the latter are united immovably by suture; while the two remaining facial bones, the lower jaw and the hyoid, are movable, as are the three small bones in each tympanic cavity.

The **skull** is bilaterally symmetrical, and should be examined first as a whole. Seen from above (**norma verticalis**) it is oval with the broader end behind (fig. 303). The bones seen in this view are the frontal before and the parietals behind, united at the transversely placed **coronal suture**. The two parietals unite medially at the **sagittal suture**, which ends posteriorly at the apex of the **lambdoidal suture**, beyond which, at the hindmost part of the skull, a small area of the occipital bone is visible. The most bulging parts in this aspect are the frontal eminences antero-laterally, and the parietal eminences postero-laterally. The mid-point of the coronal suture where it joins the sagittal is named the **bregma**; the median angle of the lambdoidal suture is the **lambda**. A small hole usually traverses each parietal bone close to the sagittal suture at its hinder third. The region of these parietal foramina is often flattened, and is called the **obelion**.

Viewed from behind (**norma occipitalis**—fig. 304) the skull appears somewhat pentagonal with rounded angles and sides; the upper median angle is at the sagittal suture, the upper lateral at the parietal eminences, between these is the rounded upper part of the parietal bone. The inferior lateral angles are at the **mastoid processes**, which are rough irregular out-

growths of the temporal bones for the attachment of muscles. Between the two mastoid processes is an irregular *intermastoid basal line* forming the fifth side. The surface is divided by the three sutures radiating from the lambda; the sagittal ascending medially, the two halves of the lambdoidal suture descending laterally, and ending before they reach the mastoid processes on each side, by dividing each into an upper or **parieto-mastoid**, and a lower or **occipito-mastoid** suture. Between these is the mastoid portion of the temporal bone.

About 7.5 cm. below the mid-point of the lambdoidal suture, as seen in this aspect, is a median **occipital protuberance**, from which on each side a **superior nuchal line** passes outwards, ending by becoming continuous with the hinder edge of the mastoid process; over this line there is often a second line the *linea nuchalis suprema*. A vertical **occipital crest** descends from the protuberance in the middle line. The triangular area between the lambdoidal suture and the superior nuchal line is called the **squama occipitis**.

The profile view of the skull (*norma lateralis*—fig. 305) appears more

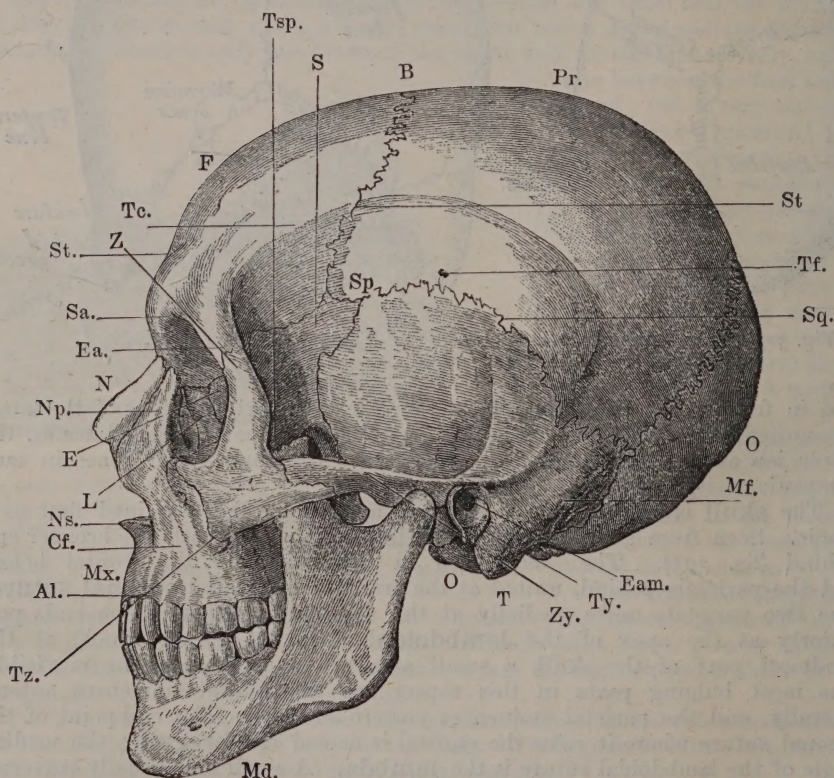


Fig. 305.—Norma lateralis.

complicated, presenting a continuously curved outline above and behind, while below and in front the base and facial region appear more irregular. Behind, the side of the occipital bone (O) rises to the lambdoidal suture, which runs downwards and forwards to its bifurcation. Above and in front of this suture the parietal bone (Pr.) rises convexly forward to the coronal suture, where it

joins the frontal (F). On the profile of the frontal bone is the **frontal eminence** projecting above the shallow *sulcus transversus* (St.) of the forehead; below which the **superciliary arch** (Sa.) forms the lower limit of the forehead and lies above the upper rim of the orbit. This rim ends externally at the **external or malar angular process** of the frontal bone (Ea.), from the back of which a projecting arched line, the **temporal crest** (T.C.), ascends backwards crossing the coronal suture at a point called the **stephanion** (St), and marking off the lower and outer part of the frontal and the lower third of the parietal. This crest descends steeply behind to the notch in the back of the temporal bone at the front end of the parieto-mastoid suture, and then turns forwards horizontally above the ear passage. This line is generally double and more prominent anteriorly, single and fainter behind. The area below it is smooth and is called the **temporal fossa** (Tf.). The bone above it is dotted with minute vascular holes.

The lower edge of the parietal bone is overlapped by the upper margin of the squamosal plate of the temporal, forming the **squamous suture** (Sq), which extends backwards and downwards to the parieto-mastoid suture. In front, between the squamous and coronal sutures, is the short **spheno-parietal suture** (Sp), at which the anterior inferior angle of the parietal joins the great wing of the sphenoid (S). This latter bone is seen in front of the squamous plate of the temporal, extending downwards to the deepest part of the temporal fossa, and sinking out of sight as it is crossed by a rough transverse **infratemporal crest** (Tsp) whose plane forms the lowest limit of the temporal fossa.

Behind the mastoid process is the variable **mastoid foramen** (Mf) transmitting vessels, and in front is a larger opening, the ear-passage or **external auditory meatus** (Eam), bounded below by the rough-edged tympanic bone (Ty). A line drawn from the front of one meatus to its fellow across the top of the skull passes through the bregma. Above and in front of this a prominent horizontal process juts forwards and outwards, continued forwards as a free horizontal archway below the temporal fossa (the **zygomatic arch**, Zy); its hinder half is a process of the temporal; its forepart is a portion of the malar bone (Z). The upper edge of its malar part is continued upwards to join the external angular process of the frontal, thus completing the limit of the temporal fossa. The bones forming the floor of this fossa are parts of the temporal, parietal, frontal, sphenoid, and malar. Below the zygomatic arch and appended to the back of the upper jaw, the outer surface of the **external**

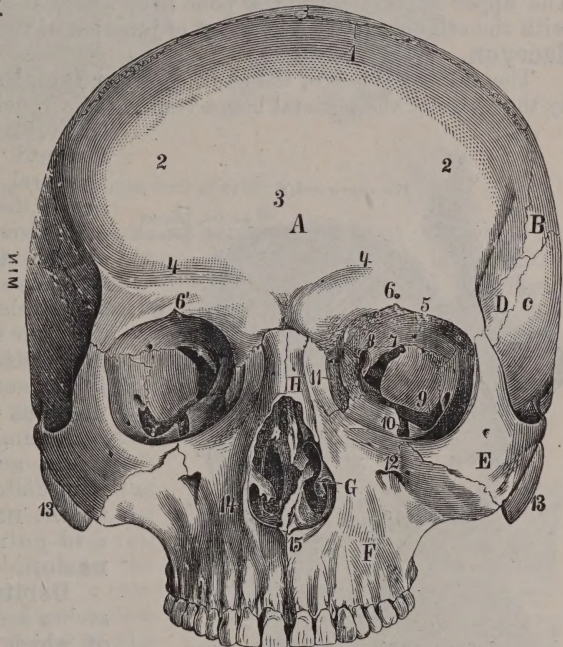


Fig. 306.—Norma facialis.

pterygoid plate of the sphenoid projects. Between this and the auditory meatus the long, pointed **styloid process** extends downwards and forwards, concealed in the figure by the lower jaw (see 17, fig. 310).

The malar, as seen in this view, forms, in front and above, the outer margin of the orbit; below, its edge is rough for the attachment of the *masseter* muscle; and anteriorly it ends on the face in the **malo-maxillary suture** (Tz.). The lower border of the upper jaw-bone or maxilla (Mx.) is the **alveolar arch**, in which the teeth are fixed. Above this and below the lower edge of the orbit is a shallow **canine fossa** (Cf.), bounded in front by a rounded vertical ridge, formed by the socket for the canine tooth. Medially above the alveolar arch the **nasal spine** (Ns.) projects, at the lower limit of the **pyriform** or anterior nasal **aperture**; this ends above at the lower border of the nasal bones (N), which make the ridge of the nose here seen in profile. These nasal bones lie internal to, and above, the **nasal process** of the maxilla (Np), which articulates above with the **internal angular process** of the frontal, which is the inner end of the superciliary arch. Grooving the orbital surface of the nasal process of the maxilla, is the **lacrymal fossa** for the accommodation of the tear-sac, bounded behind by the sharp **lacrymal crest** of the lacrymal bone (L). The upper edge of this little bone here articulates with the frontal, its hinder with the ethmoid (E). The point of junction of these three bones is named the **dacryon**.

The full-face view of the skull (**norma facialis**—fig. 306) is limited above by the bulge of the parietal bones behind the coronal suture, and by the front of the squamosal (c) at each side. The forehead is narrowest between the temporal crests, about half an inch above the external angular process; and about this level it presents a shallow **transverse sulcus**, above which are the frontal eminences (2-2), while below are the superciliary arches (4) above the **supraorbital margins** (5), which are interrupted near their inner ends by the **supraorbital notches** (6). Internal to the internal angular process in the middle line is a smooth area, the **glabella**, immediately above the depression for the **naso-frontal suture**. The mid-point of this suture is the **nasion**.

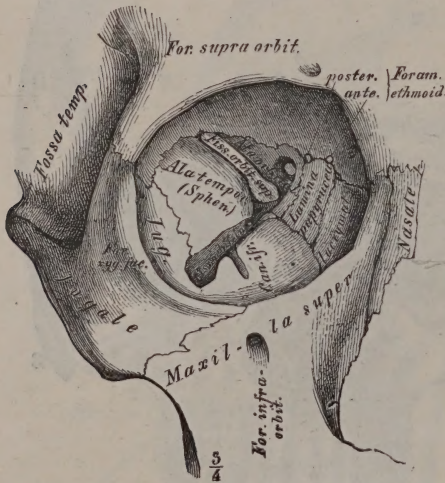


Fig. 307.—Orbit seen from the front.

its fellow, so that, if prolonged, they would meet under the bregma. The orbital margin is of very compact bone, and somewhat quadrilateral, with rounded angles. Above, it is formed by the supraorbital margin of the frontal bone; externally, by the orbital edge of the malar; internally, by the nasal process of the maxilla; below, by the infraorbital margins of malar and maxilla.

The roof of the cavity is concavely arched, and is formed of the orbital plate of the frontal anteriorly, and of the lesser wing of the sphenoid posteriorly; these are joined by a transverse suture (fig. 306, 7). At the deepest point of the roof where the lesser wing joins the inner wall of the orbit is the

Orbits.—Below the superciliary arches are the **orbits** (fig. 307), each of which is a conical cavity whose axis converges backwards to that of

round **optic foramen** (fig. 306, 8) for the transmission of the optic nerve and ophthalmic artery.

The outer wall inclines forwards and outwards, and is made of the flat quadrate orbital surface of the great wing of the sphenoid, which unites by suture above with the frontal, in front with the malar. Behind, it is separated

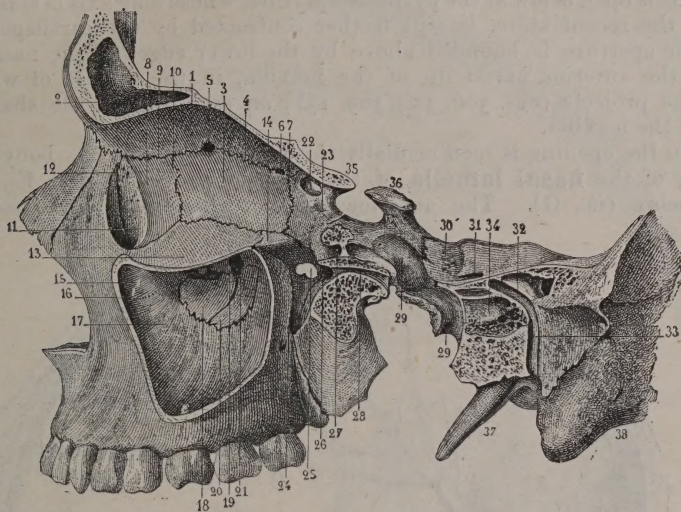


Fig. 308.—Inner wall of orbit.

from the lesser wing by the large oblique **sphenoidal fissure** (fig. 307, *Fiss. orb. sup.*), transmitting several large orbital nerves; below, it is separated from the maxilla by the **spheno-maxillary fissure** (fig. 306, 9), which is bridged by membrane and blocked up chiefly by fat.

The orbital floor slopes from within downwards and outwards, and is bounded externally by the **spheno-maxillary fissure**. It is formed chiefly by the orbital plate of the maxilla (fig. 308, 13), with a small part of the malar anteriorly at the margin, and the small triangular orbital plate of the palatine bone posteriorly, marked off from the maxilla by a transverse suture (*ib.*, 14). The floor is continued internally into the inner wall, which is nearly parallel to that of its fellow, and consists from before backwards of the nasal process of the maxilla (*ib.*, 12), the lacrymal bone (*ib.*, 8), grooved in front for the lacrymal sac (11), but flat behind where it joins the quadrate os planum of the ethmoid bone (3), whose upper border unites with the frontal (4), its hinder (7) with the sphenoid and palate, and its lower with the maxilla. The body of the sphenoid (23) completes the hinder part of this inner wall. Between the frontal and ethmoid bones are the two **ethmoidal foramina**, anterior and posterior (5 and 6).

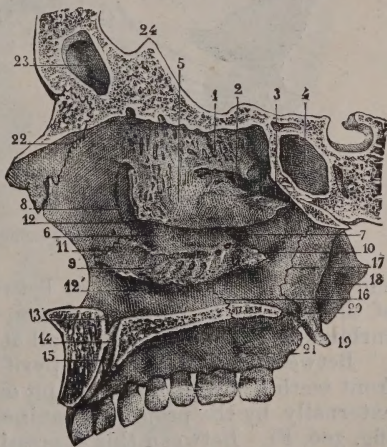


Fig. 309.—Outer wall of the nasal fossa.

Seven bones thus enter into the wall of each orbit, but the frontal, sphenoid, and ethmoid are single bones, common to the two orbits; so the orbital region, both sides together, consists of eleven bones.

The **nasal region**, between and below the orbits, is closed in above by the nasal bones (figs. 306, H; 309, 22), which unite medially in the **internasal suture**. It is open below at the pyriform aperture, whose long axis is vertical, and which, in the recent state, is still farther contracted by the cartilages of the nose. The aperture is bounded above by the lower edges of the nasal bones, below by the anterior narial lip of the maxilla, in the middle of which the nasal spine projects (figs. 306, 15; 309, 13); on each side is the sharp nasal margin of the maxilla.

Within the opening is seen medially the anterior edge of the bony septum, consisting of the **nasal lamella** of the ethmoid above (fig. 310, F), and the **vomer** below (*ib.*, G). The anterior edges of these two slope backwards,

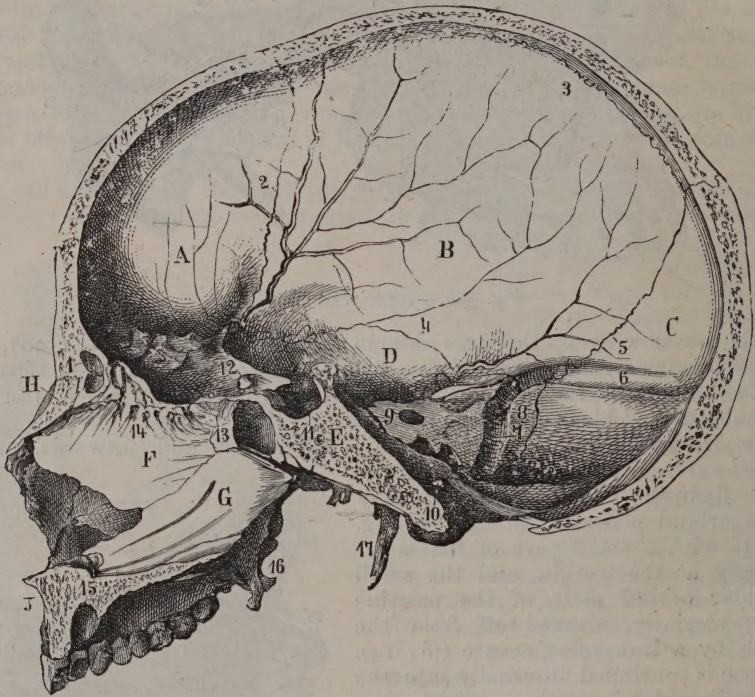


Fig. 310.—Sagittal section of skull, $\frac{1}{2}$.

and so leave an angular space between them filled by cartilage. On each side of this septum is the **nasal fossa**, into which projects the front of the inferior turbinal bone from its outer wall at its lower third (fig. 309, 9).

Between the edge of the pyriform aperture above and the sockets of the front teeth below, is a shallow pit on each side, the **myrtiform fossa**, bounded externally by the projecting canine socket, outside which is the **canine fossa** (fig. 306, F). Between this depression and the orbital brim is the **infraorbital foramen** (*ib.*, 12). The malar bone and alveolar arch complete the appearances seen on this aspect.

The inferior aspect of the skull (**norma basilaris**—fig. 311) is very irregular. Upon this surface the **foramen magnum** appears, through which the

spinal canal communicates with the cranial cavity. Behind this opening is the nuchal plane of the occipital bone, divided into lateral halves by the occipital crest (*linea nuchae mediana*), which extends from the protuberance to the foramen

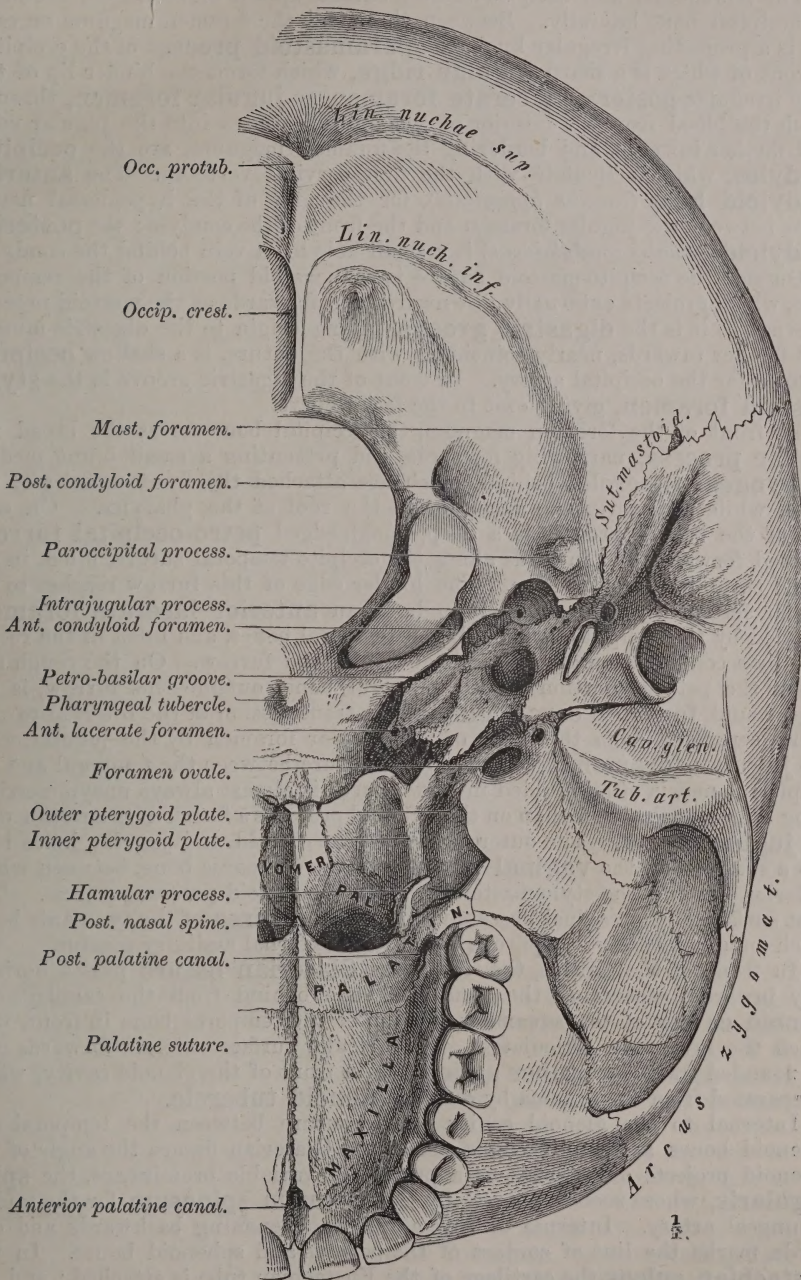


Fig. 311.—Norma basilaris.

magnum. On each side of this are two transversely curved lines, **superior and inferior nuchal lines** for muscular attachments. The squama occipitis expands behind the uppermost of these and limits the region in this aspect.

The lambdoidal and occipito-mastoid sutures appear on each side, bounding the occipital bone laterally. Between these and the foramen magnum on each side is a projecting irregular knob, the **paramastoid process** of the occipital, in front of which is a sharp **jugular ridge**, which forms the hinder lip of the large irregular **posterior lacerate foramen** or **jugular foramen**, through which the blood from the interior of the cranium passes into the jugular vein. Still farther inwards, and bordering the foramen magnum, are the **occipital condyles**, which articulate with the first cervical vertebra. The **anterior condyloid hole** (*canalis hypoglossi*), for the exit of the hypoglossal nerve, opens between the jugular foramen and the front of the condyle; the **posterior condyloid** (*canalis condyloideus*) is a small hole for a vein behind the condyle.

Outside the occipito-mastoid suture is the mastoid portion of the temporal bone, which projects externally downwards and forwards as the mastoid process. Internal to it is the **digastric groove**, giving origin to the digastric muscle. Still farther inwards, nearly coinciding with the suture, is a shallow **occipital groove** for the occipital artery. In front of the digastric groove is the **stylo-mastoid foramen**, giving exit to the facial nerve.

In front of the foramen magnum, the occipital bone forms the broad flat **basilar process**, narrowing forwards, and presenting a small blunt median **pharyngeal tubercle**, behind which are attached the front muscles of the spine, while anteriorly the bone forms the roof of the pharynx. On each side of the basilar process is a deep, rough-edged **petro-occipital furrow**, directed forwards and inwards along the occipito-temporal suture, filled, in the recent state, by fibro-cartilage. The hinder edge of this furrow reaches to the jugular foramen, and in front it ends in an **anterior lacerate foramen**, bounded by the occipital, sphenoid, and temporal bones, and filled in the recent state by a continuation of the cartilage filling the furrow. On the rough surface of the petrous portion of the temporal bone, outside this furrow, is the large, round, **foramen caroticum**, for the transmission of the internal carotid artery, separated from the front of the jugular foramen by the jugular crest. The **jugular foramen** lies in the line of suture between the temporal and the occipital bones, is often divided into two parts, is almost always unsymmetrical, being larger on the right than on the left, and presents a fossa on its anterior wall, the **jugular fossa**. The outer border of the carotid and jugular holes rises into a sharp crest, the **vaginal process** of the tympanic bone, between whose posterior end and the stylo-mastoid foramen the styloid process projects. The front surface of the vaginal process is the **glenoid area** of the tympanic bone, which ends externally in the rough lip of the external auditory meatus.

In front of the meatus, the transverse **Glaserian fissure** passes horizontally inwards, separating the tympanic bone behind from the cartilage-clad **glenoid cavity** of the squamous portion of the temporal bone in front, with which the lower jaw articulates. The articular surface extends forwards over the rounded transverse **tuber articulare** in front of the glenoid cavity, which is separated from the zygoma by a small **glenoid tubercle**.

Internal to the glenoid cavity is the suture between the temporal and sphenoid bones, and at the inner end of the Glaserian fissure the angle of the sphenoid projects downwards as a process of variable prominence, the **spina angularis**, whose root is pierced by the **foramen spinosum** for the middle meningeal artery. Internal to this a furrow, deepening backwards and outwards, marks the line of contact of the petrous and sphenoid bones. In this **Eustachian sulcus** the cartilage of the Eustachian tube is attached; and the mouth of that tube, and of the canal for the *tensor tympani* above it, open at its

posterior end. In front of the groove is the **foramen ovale** for the exit of the inferior maxillary nerve; external to which the great wing of the sphenoid rises to its temporal crest.

The anterior portion of the base of the skull is occupied by the structures connected with the upper jaw. The **choanæ** or posterior nasal openings lie medially in front of the basilar process, separated from each other by a median thin lamella of bone, the vomer, and bounded externally by the vertical **internal pterygoid plate**, descending from the sphenoid bone. This begins above in a stumpy **pterygoid tubercle**, which underlies the cartilage of the foramen lacerum anterius; outside which is a small shallow depression, the **scaphoid fossa**. The internal pterygoid plate ends below in an out-turned hook, the **hamular process**, around which the tendon of the *tensor palati* muscle winds. Outside the internal pterygoid plate, and separated from it by a deep **pterygoid fossa**, is the more prominent and ragged-edged **external pterygoid plate**, whose outer surface is directly continuous with the great wing of the sphenoid. Between the two pterygoid processes at their lower end, and directly external to the hamular process, the **pyramidal process** of the palatine bone appears embedded in a notch at the lower end of the pterygoid fossa.

The lower surface of the upper jaw presents the semi-elliptical alveolar arch with its sixteen tooth-sockets, bounding the rough concave **hard palate**, the hinder fourth of which is the lower surface of the palate process of the palatine bone; the rest consists of the palate process of the maxilla. In the middle line is the **palatine suture**, pierced in front by the **anterior palatine canal** (foramen incisivum), while behind and externally on each side is the **posterior palatine canal**.

The Zygomatic Fossa.—One of the most complex regions of the skull is that internal to the zygomatic arch. This **zygomatic fossa** lies below the temporal fossa, and is bounded behind by the articular tubercle of the temporal and the spine of the sphenoid; internally, by the external pterygoid plate; in front, by the tuber maxillare and the back of the malar bone; and externally, by the malar and zygomatic process. A narrow vertical pit, the **pterygo-maxillary fossa**, passes inwards from the deepest part of this fossa, bounded behind by the pterygoid plates, in front by the maxilla; above, it communicates with the end of the speno-maxillary fissure and through it with the orbit; internally, it is limited by the upper part of the vertical plate and sphenoidal process of the palatine bone, and communicates by the speno-palatine foramen with the upper and back part of the nasal fossæ.

117. INTERIOR OF THE SKULL.—The skull should be sawn through along a line horizontally drawn around it, 2 cm. above the occipital protuberance, and 3 cm. above each external angular process. When the roof is removed by this section, the inner surface of the base appears divided into three **fossæ**—**anterior, middle, and posterior** (fig. 312). These in the recent skull are lined by a glistening fibrous membrane, the dura mater, whose outer layer is the internal periosteum of the skull. On the front wall of the anterior fossa is a median crest on the frontal bone, ending below at a small hole (**foramen cæcum**) in the suture between the frontal and ethmoid bones. Behind this is a sharp thin median eminence on the ethmoid (**crista galli**), on each side of which is a narrow flat **cribriform plate**, pierced with numerous holes for the transmission of the olfactory nerves. Behind the cribriform plate, the **ethmoidal spine** of the sphenoid bone projects forward in the median line. The upper surface of the body of the sphenoid is flat, as far as a transverse sulcus for the optic commissure. This is bordered posteriorly by a rounded transverse eminence, the **olivary process** (tuberculum ephippii), on each side of which is the round **optic foramen**, communicating with the orbit. External to this hole is the sharp **anterior clinoid process**, the hinder angle of the **lesser wing** of the sphenoid. The convex orbital process

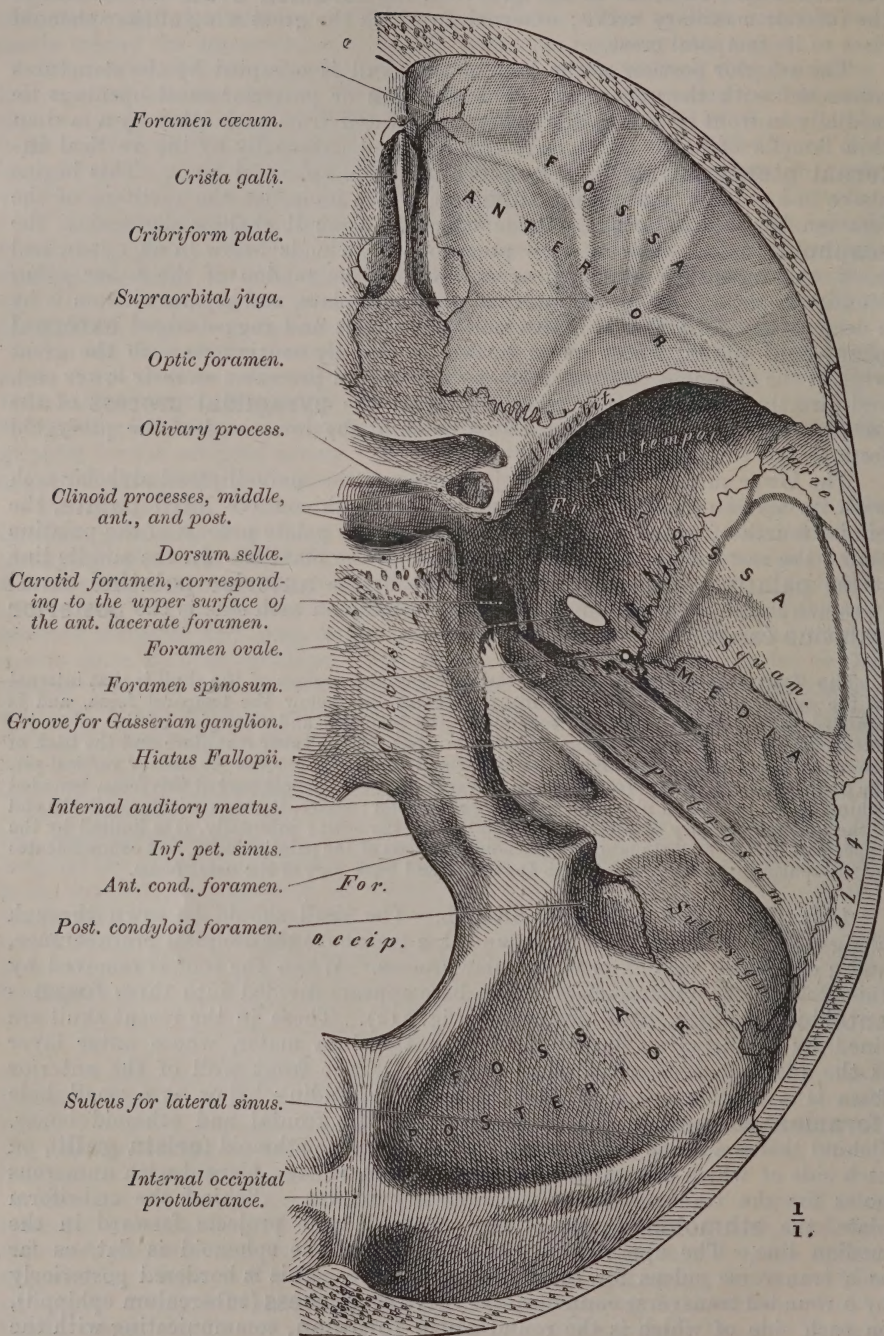


Fig. 312.—View of right half of base from above, the roof of the skull having been removed.

of the frontal bone, marked with ridges (**juga cerebralia**) and sulci for the brain convolutions, completes the floor of the anterior fossa on each side. The suture between the frontal and the lesser wing of the sphenoid crosses the hinder fourth of the fossa transversely.

The middle fossa forms a narrow deep **pituitary fossa** or **sella turcica** medially, on the upper surface of the body of the sphenoid behind the olivary process. This hollow is bounded behind by a ridge (**dorsum ephippii** or **sellæ**), whose lateral angles are the **posterior clinoid processes**. Outside this is a **sigmoid groove** for the carotid artery, starting from the top of the anterior lacerate foramen, outside and in front of which is the **great wing** of the sphenoid. This wing joins the squamous bone externally by a concave suture and the petrous portions of the temporal bone posteriorly. At the front of the fossa, between the lesser and greater wings of the sphenoid, is the **sphenoidal fissure**, communicating with the orbit. Behind the fissure is the **foramen rotundum** (*F.r.*) for the exit of the superior maxillary nerve; and still farther backwards and outwards is the **foramen ovale** for the inferior maxillary nerve. Behind and external is the **foramen spinosum**, situated in the hindmost point of the great wing; from it two ramifying grooves for branches of the middle meningeal artery ascend outwards on the inner surface of the temporal, sphenoid, and parietal bones.

The hindmost part of the middle fossa is the upper surface of the petrous portion of the temporal bone, upon which, from within outwards, are to be noticed—a depression for the Gasserian ganglion (**impressio trigemini**) above and outside the carotid foramen, then a pair of small holes, of which the larger or **hiatus Fallopii** is posterior, the other, for the small petrosal nerve, is in front. Outside there is an eminence corresponding to the superior semi-circular canal of the ear, **eminentia arcuata**, and along the hinder and inner margin of the fossa is a groove for the superior petrosal sinus. The sides and floor of the fossa are marked by depressions for the cerebral convolutions, separated by ridges corresponding to the involutions.

The posterior fossa is the deepest and most extensive. Its front wall slopes medially down from the back of the **dorsum ephippii**. The upper part of this **clivus** is formed by the body of the sphenoid, the lower by the basilar process of the occipital, but these bones unite at the age of 21. At the bottom of this slope is the **foramen magnum**, on each side of which anteriorly is the **anterior condyloid foramen**, over which rises the **jugular eminence** on the inside of the irregular **foramen jugulare**. This last foramen is often divided into two by a bony bridge, the **intrajugular process**. From the front of this foramen, a sulcus ascends forwards along the suture between the basilar process and the petrous bone, lodging the inferior petrosal sinus. Above the jugular foramen, on the hinder surface of the temporal bone, is the **internal auditory meatus** for the facial and auditory nerves. From the back of the jugular foramen, the deep furrow for the sigmoid and its continuation, the lateral sinus, extends at first downwards, backwards, and outwards on the lateral process of the occipital; then it ascends backwards on the inside of the mastoid part of the temporal; then, crossing the posterior inferior angle of the parietal bone horizontally, it passes inwards to the middle line of the occipital. This groove isolates the **inferior occipital fossæ**, which are medially separated from each other by the vertical **internal occipital crest** and occupied by the lobes of the cerebellum. Above the level of the sinus are the **superior occipital fossæ**, separated from each other by a median groove for the superior longitudinal sinus.

Having examined the skull as a whole, each bone should next be studied separately.

118.—THE OCCIPITAL BONE is lozenge-shaped, forming part of the

hinder and basilar surfaces of the skull, and consisting of four parts, which meet around the foramen magnum, represented by separate bones in lower vertebrates. These are the **supra-** and **basioccipitals** medially and the two **exoccipitals** laterally.

The **supraoccipital** is on its outer surface divided into two areas. The upper, or **planum interparietale** (fig. 313, I), is smooth, convex, and

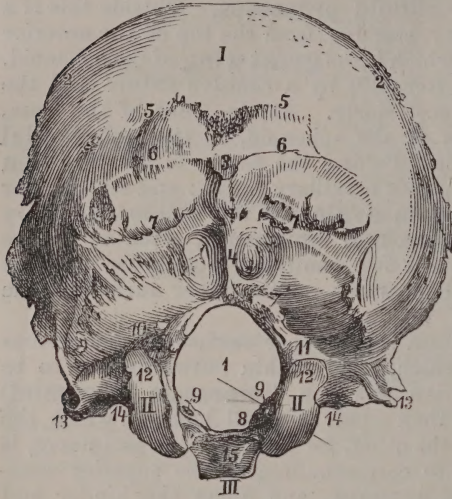


Fig. 313.—Occipital bone, hinder view.

triangular, covered by the scalp, and joining the parietal bones above and laterally by its lambdoid edge. The lower, or **planum nuchale**, is uneven, bounded laterally by the occipito-mastoid suture, and marked off from the former by the curved **superiornuchallines**—**lineæ nuchæ suprema** (*ib.*, 5) and **superior** (6)—the inner third of whose upper edge gives origin to the *trapezius*, its outer third to the *occipito-frontalis*. In the middle line is the **occipital protuberance**, to which the *ligamentum nuchæ* and the upper edge of the *biventer* are attached. To the outer part of the superior line the *sterno-mastoid* is inserted above, the *splenius capitis* below. To the **occipital crest**, which descends from the protuberance, a vertical extension of the *ligamentum nuchæ* is attached.

Below the inner half of the superior nuchal line is a large area for the insertion of the *complexus*, inferior to which is the **inferior nuchal line** (7). This, and the space below it, give insertion to the *superior oblique* and the *greater* and *lesser recti capitis*, the former above and externally, the two latter nearer the middle line.

The inner or cerebral surface of the supraoccipital is divided into four fossæ by a cross of grooved ridges radiating from the central **internal occipital protuberance** (fig. 314). The upper vertical ridge is channelled by a **sulcus** for the superior longitudinal sinus. The lower is a sharp **internal occipital crest**. On each side is a **transverse sulcus** for the lateral sinus. The two **superior occipital fossæ** are occupied by the occipital lobes of the cerebrum; the **inferior**, whose floor is very thin, by the cerebellum.

The **exoccipital** portions form on each side the lateral boundary of the foramen magnum. On the basilar surface of each is the **articular condyle**, whose anterior part invades the basioccipital. These condyles are somewhat elliptical, 15 mm. asunder in front, 38 mm. behind (fig. 313, II). Their long axes converge forwards, and if prolonged, would meet at an angle of 66° under the basilar process. Each condyle presents an everted curved skew surface, whose inner border is lower than its outer, and whose front end is lower than its back. The medial surface of each is rough anteriorly for the occipito-odontoid ligament, and a line around each gives attachment to the capsular ligament. Behind each condyle is a **condyloid fossa**, receiving the hinder edge of the articular cavity of the atlas in extension of the head, and usually perforated by the **posterior condyloid foramen** for a vein which traverses the bone forwards to the lateral sinus (fig. 312, 10). External to the condyle, in the line of junction of the basi- and exoccipitals, is the **anterior condy-**

loid foramen for the hypoglossal nerve (9). A rough **jugular ridge**, into which the *rectus capitis lateralis* is inserted, extends outwards from the condyle, and ends in a more or less prominent **paramastoid** or **paroccipital process**, whose sharp lower and front edge gives attachment to the prevertebral fascia, and forms the hinder margin of the jugular foramen (fig. 313, 13).

On its intracranial surface rises the rounded **jugular eminence**, having the opening of the anterior condyloid foramen on its inner aspect, and that of the posterior on the outer side. Outside the opening of the latter is the groove for the sigmoid sinus, ending at the jugular foramen.

The **basioccipital** or basilar process (fig. 312, 15) forms the thin front edge of the foramen magnum, rapidly thickening, but narrowing transversely as it extends forwards to its anterior surface, which enters into the **spheno-occipital suture**. Its lower surface is flattish, and to its median **pharyngeal tubercle** is attached the mid-point of the wall of the pharynx. Behind this are lateral transverse markings for the *recti capitis antici* muscles, while in

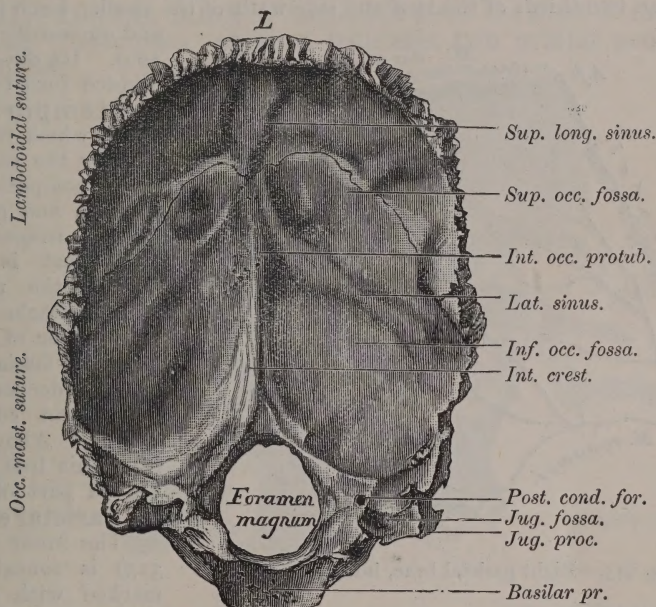


Fig. 314.—Inner surface of occipital bone.

front the bone is covered with the thick mucous membrane of the pharyngeal roof. This surface is palpable in life by the finger introduced into the pharynx and turned upwards. The roughly rounded lateral margins enter into the occipito-petrosal synchondrosis, and on the intracranial surface are grooved for the inferior petrosal sinuses. The intracranial surface (the **clivus**) is transversely concave above for the medulla oblongata.

The **foramen magnum** (1) is oval, with its long axis sagittally directed; its anterior edge is on the level of the external auditory meatus; its posterior is on a line with the back of the mastoid process, and it is bisected by a line joining the hinder ends of the two condyles. It transmits the spinal cord and its membranes, the vertebral arteries, the anterior and posterior spinal arteries, the first tooth of the denticulate ligament and the broad occipito-axoid and check ligaments, and the spinal accessory nerves.

The occipital bone articulates by suture with five bones, by condylarthrosis with one; it is pierced by five holes, and forms part of the boundary of two; it has seven named processes and seven named ridges; and gives origin to two pairs and insertion to ten pairs of muscles.

Development.—The planum interparietale ossifies chiefly in membrane, the rest of the bone is preformed in cartilage. *Two* unequal centres arise close together in the basioccipital in the tenth week, and become confluent by the end of the twelfth week. *One* centre arises in the front of the exoccipital area of cartilage in the twelfth week, and *two* early uniting centres in the planum nuchale about the same time. The parostotic centres in the interparietal plate appear about the thirteenth week, and are variable in number from *two* to *four* or more; but they coalesce into one before the fifteenth week, and unite with the nuchal plate by the end of the fourth month. The two nuchal centres are separated behind the edge of the foramen magnum by a fissure of moderate width until the end of the fifth month. At birth the bone consists of its four elements, whereof the exoccipitals join the supraoccipital at four years; the basioccipital unites at five and a-half; and by seven the foramen magnum has attained its adult size. The female bone has a more rounded planum interparietale and smaller protuberances.

Beneath and in front of the anterior condyloid foramen is a fine vertical ligamentous band, the *ligamentum hypoglossi*, which binds the hypoglossal nerve forwards, and is sometimes ossified.

119. THE PARIETAL BONES are two in number, symmetrical, forming more than two-thirds of the roof and side walls of the skull. Each is four-sided



Fig. 315.—Right parietal bone, inner surface.

and outwardly convex (fig. 304). Its outer surface is divided into two areas by the **temporal crest**, above which it is covered only by the scalp; below, it is compact, minutely striated, and gives origin to the *temporal* muscle. The crest is generally double, the upper crest giving attachment to the outer layer of the strong temporal fascia, the lower to the deeper layer of fascia and edge of the muscle. Above and behind this line is the most convex part of the bone, the **parietal eminence**.

The inner surface (fig. 315) is concave, smooth, marked with depressions

and ridges for cerebral convolutions, and deeply grooved by the branches of the middle meningeal artery, which run upwards and backwards from below. One large groove coasts along the front edge, another begins at the middle of the lower border and ascends, sending branches backwards. Along the upper edge is a wide half-groove, often slightly marked, for the superior longitudinal sinus; at the side of which the adult bone shows small irregular pits for wart-like outgrowths of the brain membranes (glandulæ Pacchioni). At the hinder and lower angle is a short, wide groove for the lateral sinus (fig. 310, 6). The most concave part of the bone internal to the parietal eminence is the **parietal fossa**.

The anterior margin enters into the coronal suture, overlapping the frontal below, but being overlapped by it above. The upper or sagittal edge joins its fellow in the sagittal suture, the hinder joins the occipital in the lambdoidal. The lower or occipital edge thins in the middle to a sharp concave edge, and is fluted on the outer surface, where it is overlapped by the squamous plate of the temporal, with which it forms the squamous suture (fig. 305, Sq). In front and

behind this are two truncated acute angles, the anterior inferior, or sphenoidal, being the most prominent; it is nearly horizontal, and its lower margin forms the spheno-parietal suture with the great wing of the sphenoid (fig. 305, Sp). The second or posterior inferior angle enters into the parieto-mastoid suture. The anterior superior or bregmatic angle is nearly a right angle; the posterior or lambdoid is obtuse. A little above this last angle, and close to the sagittal suture, is the small **parietal foramen** (fig. 304) transmitting a small vein. The sagittal suture is simpler in pattern opposite this point.

Development.—Each parietal ossifies in membrane from one centre, which appears at the parietal eminence in the seventh week. From this point, bony growth radiates, but not equally, as there is often a fissure which passes obliquely from the parietal eminence to the hinder sixth of the sagittal suture. This is usually closed in the fifth month, but may persist and become the seat of a meningocele. At birth, both the frontal and occipital angles are rounded, leaving at the bregma and the lambda unossified spaces, the **fontanelles**.

The parietal has one centre of growth, one muscular origin, one foramen, one prominence, four angles, six sutures, and three sets of vascular grooves.

120. THE FRONTAL BONE is single, and forms the front of the brain-case, consisting of four parts: **squama frontalis**, two **orbital processes**, and **nasal spine**.

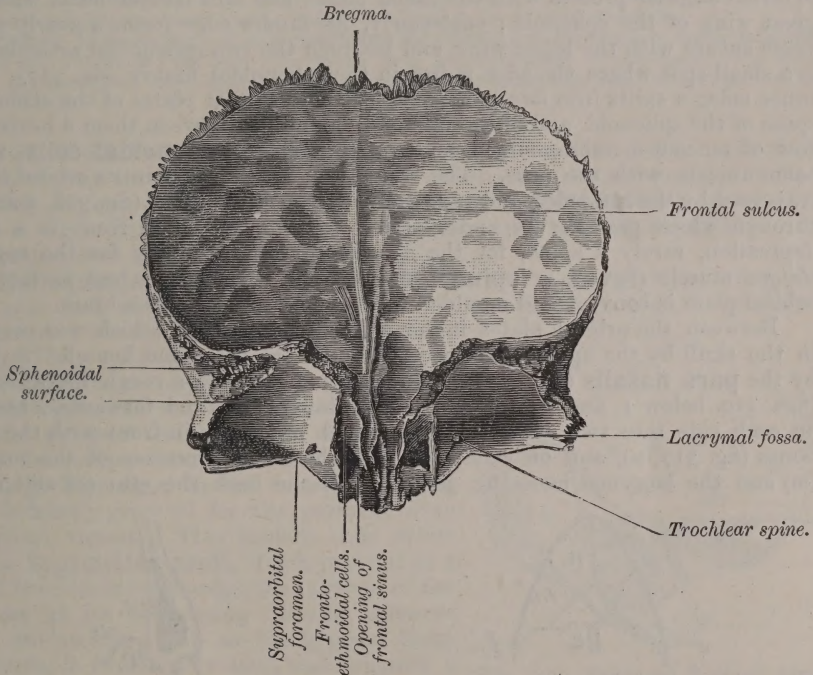


Fig. 316.—Frontal bone, cerebral surface.

The **frontal squama** is the largest portion of the bone; it is convex forwards, and ends above in the toothed coronal edge, which articulates with the parietal. It presents on each side a convex **frontal eminence** (fig. 306, 2), very prominent in young bones. Below this is a shallow **suleus transversus** (*ib.*, 4), under which is the concave **supraorbital margin** (*ib.*, 5), which is pierced or interrupted at its inner third by the **hole** or **notch** for the supraorbital nerves and vessels (*ib.*, 6). Above each orbital margin, and internal to the plane of the supraorbital notch, is the projecting **superciliary arch** in the

male (fig. 305, Sa), corresponding to an air-cavity within the bone, the **frontal sinus** (figs. 308, 2; and 309, 23). To the lower part of this arch are attached fibres of the *orbicularis palpebrarum* and *corrugator supercilii* muscles. Between and below the superciliary arches is a smooth spot, the **glabella** (fig. 306, below A), whose lower border retreats to the fronto-nasal suture. The supraorbital arch ends externally at the **external angular process** (fig. 305, Ea), which is often very prominent, and from the back of which the **temporal crest** (*ib.*, Tc) starts sharply on its arched course, isolating the **temporal area** behind and below it.

The cerebral aspect of the frontal squama (fig. 316) is concave, impressed slightly by the convolutions of the brain, marked by a median vertical **frontal sulcus** above for the superior longitudinal sinus, which changes below into a raised **frontal crest**, and terminates at the fronto-ethmoidal suture, in the middle of which is a hole, the **foramen cæcum**.

The **orbital plates** (fig. 316) project backwards, one from each supra-orbital margin, to form the roof of the orbit and part of the floor of the anterior cranial fossa. Each plate is concave below, with a deep depression for the lacrymal gland (**fossa lacrymalis**) externally, behind the external angular process. The outer margin of the orbital plate articulates at and behind the external angular process with the malar bone; and still farther back, with the great wing of the sphenoid; posteriorly, its hinder edge forms a nearly transverse suture with the lesser wing, and between the two sphenoidal articulations is a small spot where the edge is free in the sphenoidal fissure (fig. 307). The inner margin splits into two lamellæ, which join similar plates of the ethmoidal spine of the sphenoid, and of the ethmoid, bounding between them a horizontal row of mucous-membrane-lined cavities, the **fronto-ethmoidal cells**, which communicate with the nose. The fronto-ethmoidal suture in its orbital side is traversed by the **anterior and posterior ethmoidal holes** (fig. 308, 5 and 6), through which pass nerves and vessels. Internally and in front is a small depression, rarely a spine, for the attachment of the pulley for the *superior oblique* muscle (**fovea or spina trochlearis**). On its cerebral surface each orbital plate is convex, and moulded to the convolutions of the brain.

Between the orbital plates is the **ethmoidal notch**, which was occupied in the skull by the upper surface of the ethmoid bone, and bounded in front by the **pars nasalis** (fig. 316). This presents medially a rough **nasal spine** (figs. 310, below 1, and 317, f), projecting downwards and forwards, extended on each side into two irregular **alæ**, which articulate in front with the nasal bones (fig. 317, n), and on each side with the nasal processes of the maxillæ (m) and the lacrymal bone (fig. 308, 8). To the back the ethmoid articulates

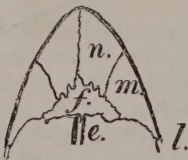


Fig. 317.—Transverse section of nasal spine and of the bones articulating with it.

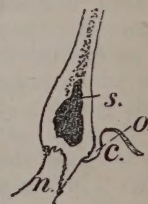


Fig. 318.—Sagittal section of frontal bone showing frontal sinus — O, foramen cæcum; c, crista galli; frontal sinus, s.

(fig. 317, e). The front of the bone above the sutural edge is rounded, and this indeterminate swelling at the inner end of the brow-ridge is called the internal angular process. Spur-like processes often dip into the intervals between the various bones which articulate herewith.

Between the nasal spine and the marginal suture of this nasal region, is

on each side the opening of the **frontal sinus** (fig. 318, *s*), which is a variable cavity lined with mucous membrane. The two sinuses are separated by a partition usually displaced to one side, and generally the right sinus is larger than the left.

Development.—The frontal develops in membrane from two large centres, arising at the lower part of the frontal eminence in the eighth week. The two lateral halves thus formed come medially in contact, and form a frontal suture, which, in 95 per cent. of skulls, closes before the end of the sixth year; in 60 per cent. it closes at the end of the second year; in about 1 per cent. it persists during life, the condition being termed “metopism.” In a very much larger percentage, however, a trace of the suture survives at the glabella. Accessory bony crusts appear, one medial for the nasal spine, appearing about fourteen years of age, consolidating at sixteen; one small bony nodule (prefrontal) appears shortly before birth on each side above the lacrymal bone, but it also speedily consolidates. A third or post-frontal ossicle arises as a series of bony grains on each side at the lower end of the coronal suture, and may synostose to the frontal, sphenoid, parietal or temporal bones, or may remain free, but most commonly becomes connected to the parietal; this is sometimes known as the pterion ossicle. The frontal sinuses begin to develop at seven years of age by the forward projection of pouches of the mucosa of the anterior ethmoidal cell into the space between the separating tables of the frontal bone.

The frontal bone articulates with twelve bones, has twelve processes, two contained cavities, two foramina, forms part of the boundary of five other holes, arises from two primary and five secondary centres, and gives origin to three pairs of muscles.

Proper Ligaments.—A **supraorbital ligament** usually converts the supraorbital notch into a foramen; the bony hole results from the ossification of this band. The trochlear, palpebral, and other ligaments will be described in connection with the soft parts of the orbit (§ 510).

121. THE TEMPORAL BONES, on each side of the lower part of the skull, contain the organs of hearing, and articulate with the lower jaw. Each consists of four elements of very different origin, which at birth have united into a single bone. These are—1, the **squamous**; 2, the **tympanic**; 3, the **petrous**; and 4, the **styloid** elements (fig. 319).

The **squamous** or upper part of the temporal is a thin plate, entering into the side wall of the middle fossa of the skull. Its front edge is serrated to articulate with the hinder edge of the great wing of the sphenoid, and its curved upper and thin hinder edges overlap the parietal in the squamous suture. Below, it unites to the petrous and tympanic bones. Its outer flat surface forms part of the temporal fossa, giving origin to the *temporal* muscle, and is faintly grooved for the posterior deep temporal vessels. This surface ends below at the **zygomatic arch**, which juts out as a shelf from its lower border, the surfaces of the process at its root being directed upwards and downwards; but as the zygoma turns forwards, it becomes twisted, and presents a smooth surface internally, a rougher surface outwards, a sharp edge (for the temporal fascia) upwards, a blunter edge for the origin of the *masseter* muscle downwards. From the root of the zygoma three ridges pass—one the **post-auricular**, horizontally backwards, forming the hinder and lower end of the temporal crest as far as the parietal notch. Below this, as the bone descends to form the outer wall of the mastoid process, is an irregular line, the remains of the obliterated suture between the petrous and squamous bones. A second **post-glenoid ridge** projects inwards in front of the external auditory meatus, and joins the anterior border of the tympanic bone. The third ridge or **tuber-**

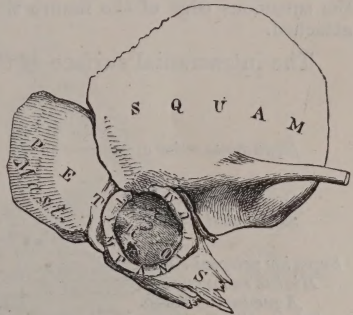


Fig. 319.—Temporal bone at birth showing its separate elements.

culum articulare (fig. 311) runs inwards and backwards, converging towards its fellow, the long axes, if prolonged, meeting in the middle line at an angle of 135° ; it bounds in front the glenoid cavity for the lower jaw. The zygoma ends in front by articulating with the malar (fig. 305) in an irregular suture. Between the front edge of the tuberculum articulare and the sphenoidal margin is the triangular **infratemporal surface**, crossed by the external pterygoid muscle, and separated from the temporal fossa by a **crista infratemporalis**.

Both the tuberculum articulare and glenoid cavity enter into articulation with the lower jaw. Where the former joins the zygoma there is a **preglenoid**

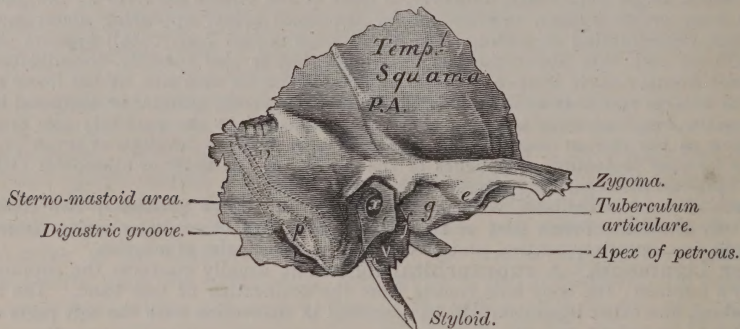


Fig. 320.—Right temporal bone, outer surface.

tubercle for the attachment of an external lateral ligament of that joint. The glenoid cavity is bounded behind by the persistent suture between the tympanic and squamous bones (**Glaserian fissure**, fig. 320, *f'*), in which a minute rough line of the petrous bone appears internally (fig. 311, above and internal to *Cav. glen.*)

Through this fissure the tympanic artery, the so-called *laxator tympani*, as well as the processus gracilis of the malleus, pass. Through a canal (**Canal of Huguier**) between the tympanic and the ridge of petrous bone internally, the chorda tympani nerve escapes. To the squamous edge of the fissure the hinder part of the capsule of the lower jaw is chiefly attached.

The intracranial surface of the squamous bone is smaller than the outer (fig.

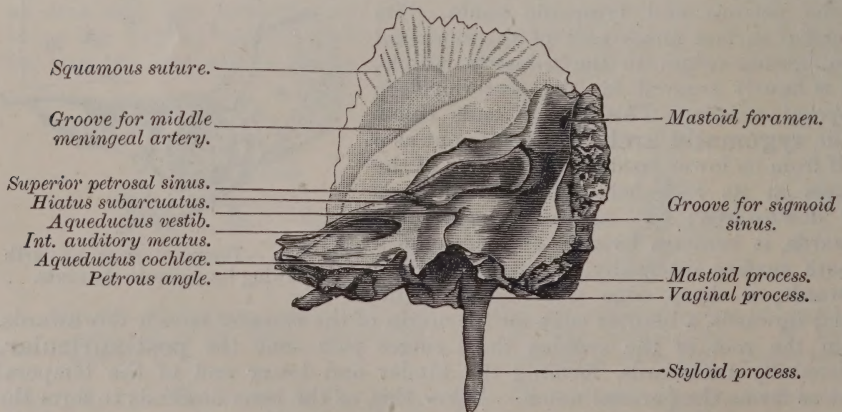


Fig. 321.—Right temporal bone, seen from behind.

310, D), being overlapped by the lower edge of the parietal. It is deeply grooved by branches of the middle meningeal artery, and is marked by sulci for the

temporo-sphenoidal convolutions of the brain. A trace of the squamo-petrosal suture often persists below as a faint fissure.

The Tympanic Bone.—The modified quadrate of lower vertebrates, partly replaced by a parostotic addition, bounds the external auditory meatus (fig. 320, *x*) and the tympanic cavity in front and below (figs. 305, Ty; 319). Its external edge is rough and concave upwards, and forms the lower and front edge of the auditory passage. In front, it is separated from the post-glenoid tubercle and glenoid cavity of the squamous by the Glaserian fissure, extending inwards nearly as far as the sphenoidal notch. Posteriorly, it is separated from the mastoid process by the **tympano-mastoid fissure**, through which Arnold's auricular branch of the vagus nerve escapes. Internally, this hinder edge fuses with the petrosal, being pierced, however, for the exit of the styloid process (fig. 320, *v*).

The tympanic bone presents two surfaces—an antero-inferior, directed towards the glenoid cavity, from which it is separated in the recent state by a lobe of the parotid gland; and a postero-superior, or tympanic, which is concave towards the meatus and tympanic cavity, of which it forms the anterior wall. The lower and hinder edge of the glenoid surface is prolonged downwards into a sharp irregular ridge, the **vaginal process** (fig. 320, *v*), which starts from the lowest part of the lip of the auditory meatus, and extends forwards and inwards to end in front of the carotid foramen. To this the front of the fascial sheath of the carotid vessels is attached.

The styloid element (figs. 320 and 321) is a slender cylindroidal spur of variable length, which emerges through the most prominent part of the vaginal process. It consists of two parts, a basal or **tympano-hyal**, embedded in the interspace between the tympanic and petrosal bones, and a projecting or **stylo-hyal** part, to whose outer edge is attached a fold of cervical fascia, the *stylo-mandibular ligament*, tying it to the angle of the mandible. Its tip is continued into a slender fibro-cartilage, the *stylo-hyoid ligament*, which is attached below to the lesser cornu of the hyoid bone. Behind and above the former ligament the *stylo-pharyngeus* muscle arises from the inner side of the root of the process;

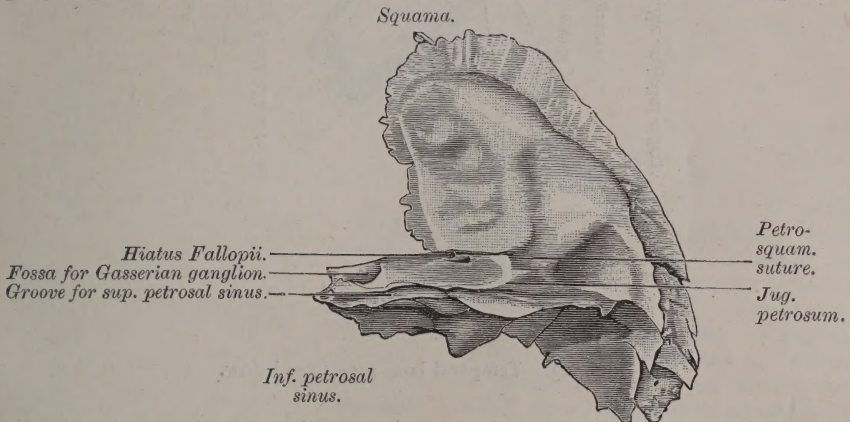


Fig. 322.—Right temporal bone, upper surface.

from the front of the tip, close to the latter ligament, arises the *stylo-glossus*. The *stylo-hyoid* muscle arises between and behind these.

The petrous bone is an irregular four-sided pyramid, whose base extends backwards to the postero-external wall of the skull, where it forms the **mastoid region**. Its truncated apex points forwards and inwards to the anterior lacerate foramen (fig. 311). Its inferior surface is basilar, its anterior is tympanic, and the superior and posterior are intracranial.

The base or mastoid region (figs. 305 and 320) is externally rough and triangular, bounded above by the post-auricular ridge and the parieto-mastoid suture, behind by the occipito-mastoid suture, and in front by the auditory meatus and the tympano-mastoid fissure. It culminates in the **mastoid process** (fig. 323), whose irregular tip is directed forwards and downwards, and into whose outer surface the *sterno-mastoid*, *splenius capitis*, and *trachelo-mastoid* are attached. Internal to it is the groove for the *digastric*, which is separated by a ridge which widens backwards from a second groove for the occipital artery, close to the hinder end of which is the **mastoid foramen** transmitting vessels. From the front and upper part of the mastoid process arise the *retrahens aurem* muscles, and a few fibres of the *occipito-frontalis*.

The mastoid region on the inner surface of the skull (fig. 320) is flattened and concave, completing the lateral part of the inferior occipital fossa, and deeply grooved where it joins the rest of the petrous bone by the downward and inward running deep sulcus for the sigmoid sinus (*ssst*).

Under the superficial layer of bone in the mastoid process, which is a descending lamella of the squamosal, are many large **mastoid cells**, which are

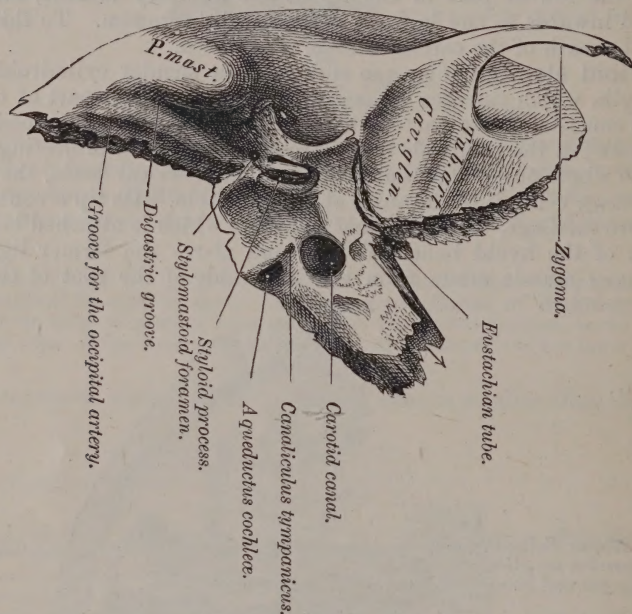


Fig. 323.—Temporal bone seen from below.

arranged in three series, an anterior superior very irregular (fig. 323), extending into the rest of the petrous bone, and communicating by a ragged passage with the back of the cavity of the tympanum, a middle set of large cells communicating with the anterior, and a third or apical set of smaller cells. The first and second of these are lined with mucous membrane and contain air, the third series are usually marrow-holding. The passage from the tympanum usually dilates under the down-growing lamella of the squamous bone into an irregular cavity, the **mastoid antrum**.

The inferior or basilar surface of the petrous bone (fig. 323) is irregular,

having its front and outer part covered by the vaginal process of the tympanic, behind which it is pierced by the **stylo-mastoid foramen** for the exit of the facial nerve. Internal to the styloid process is a smooth-walled pit, the **jugular fossa**, which forms the front part of the wall of the jugular hole, and in which is contained a pouch-like dilatation at the beginning of the internal jugular vein. On the outer wall of this fossa is a fine canal running outwards, for the auricular branch of the vagus. At its inner and front part is a small three-sided depression, the **aqueductus cochleæ**, on the margin between the inferior and posterior surfaces; this rapidly narrows to a minute canal that transmits only a shred of connective tissue. A sharp **carotid ridge** separates the front of the jugular fossa from the round opening of the **carotid canal** which lies in front, and which transmits the internal carotid artery. Upon the ridge is the minute opening of the **tympanic canaliculus** for Jacobson's tympanic branch of the glossopharyngeal nerve. The carotid canal ascends, then turns forwards and inwards, tunnelling the petrous bone to its apex, and finally runs into the upper part of the anterior lacerate foramen. Two minute **carotico-tympanic tubules** leave this canal and transmit minute nerves from the carotid plexus. The apex of the bone is rough below, and covered by the cartilage of the occipito-petrosal synchondrosis.

The posterior surface forms the antero-lateral wall of the posterior cranial fossa (fig. 321). It is grooved along its inner border by the inferior petrosal sinus (fig. 322), external to which is an outward-directed round hole, the **internal auditory meatus**, which at a depth of about 8 mm. ends in a **reniform fossa**, pierced above by the **aqueductus Fallopii** for the facial nerve, and by a group of holes below, **macula cribrosa**, for the auditory nerve. Along the upper margin, between the meatus and the superior surface, is a groove for the superior petrosal sinus, below which on a plane behind the meatus is an irregular opening, the **floccular fossa** or **hiatus subarcuatus**, very large in the young bone though often obliterated in the adult, which burrows under the superior semicircular canal. Behind and below this is the slit-like **aqueductus vestibuli**, through which a connective band unites the dura mater to the sheath of the internal ear. The aqueduct of Fallopius runs at first outwards then turns backwards and finally descends to the stylo-mastoid foramen.

The superior surface (fig. 322) forms the back part of the floor of the middle cranial fossa, and by its apex is joined to the processus petrosus posterior of the sphenoid, in front of which it is often grooved by the upturning carotid artery. Close to the apex is a pit for the Gasserian ganglion of the fifth nerve, in front of which is the ragged **anterior lacerate foramen**, from whose margin two fine grooves run backwards and outwards leading to two small holes, the hinder of which is the hiatus Fallopii for the greater superficial petrosal nerve, the foremost is for the lesser petrosal. Behind and outside these is an oblique eminence, the **eminencia arcuata** or **jugum petrosum**, over the superior semicircular canal, directly external to which the bone is thin and irregular, roofing in the tympanic cavity and named the **tegmen tympani**. This is frequently divided by a fissure into an outer or **cuneiform portion**, and an inner or **tegmen proprium**. At the posterior part of this surface there are small irregular vascular holes transmitting minute veins into the lateral sinus.

The anterior or tympanic surface is shown by removing the tympanic bone and the cartilage of the Eustachian tube, and forms the inner wall of the tympanic cavity. Externally it forms part of the wall of the external meatus as far as the annulus for the attachment of the membrane of the tympanum; next it is pierced by an irregular **antrum mastoideum** above, which communicates with the mastoid cells. Below this is the **fenestra ovalis** or opening into

the vestibule (fig. 324), placed over a convex projection or **promontory** grooved for the nerves from the different tympanic canals; still lower and a little farther back is a three-sided **fenestra rotunda** opening into the cochlea; behind this a small hollow process, the **pyramid**, juts forwards, whose base is traversed by a hole which leads into the aqueduct of Fallopius. In front and above the fenestra ovalis a thin curved plate of bone, the **processus cochleariformis**, projects backwards and upwards, ending in a free margin. This lamella is continued forwards and inwards as a partition, subdividing the space which exists between the petrous bone and the overlying layer of the tympanic bone into two tubes,

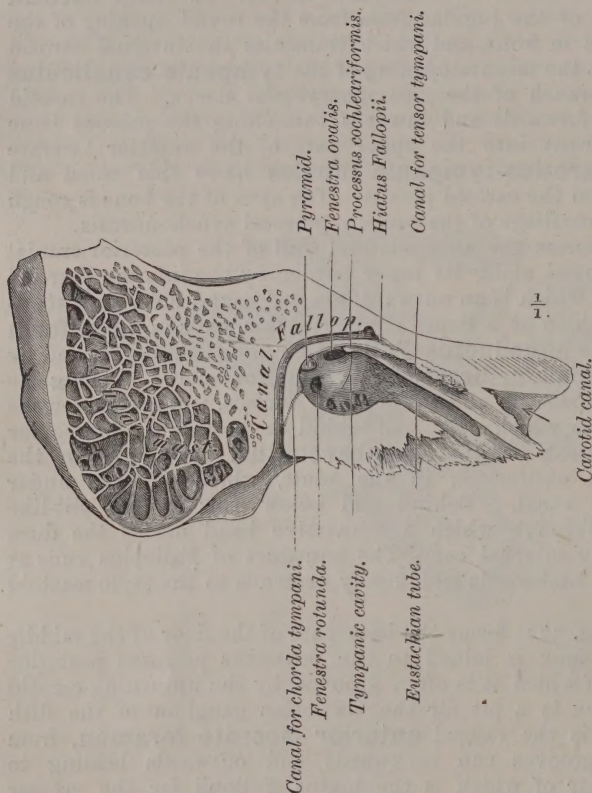


Fig. 324.—Oblique section through the temporal bone, to show the tympanic cavity and the mastoid cells.

has two centres, a tympano-hyal and a stylo-hyal, ossifying respectively about the seventh month before and the sixth month after birth, but these dates are inconstant. The tympanic ossifies from a single centre, appearing in the thirteenth week, becoming a slender ring around the membrana tympani, and extending inwards. The petrous ossifies from four centres, one opisthotic, sometimes double, posterior to the outer semicircular canal, from which the hinder part of the petrous and the mastoid portions develop; one prootic above and in front of the internal meatus; one epiotic above and external to the superior semicircular canal extending over the cochlea; and a fourth at the back of the mastoid portion. These appear in the cartilage during the twelfth and fifteenth weeks, and unite into a continuous mass by the end of the fifth month. At birth the tympanic is slender, joined at each end to the squamous and petrous bones, which are separated by a layer of cartilage. The mastoid process is undeveloped, and the glenoid cavity flat and everted. Two small bony tubercles grow out from the margin of the tympanic ring, one in front and one behind; these,

which extend from the hindmost part of the sphenopetrosal sulcus into the cavity of the tympanum. The lower of these is the **Eustachian tube**, communicating between the pharynx and the tympanum; the upper is the **canal for the tensor tympani**. The remaining anterior portion of this surface internal to the tympanic bone gives attachment to the cartilage of the Eustachian tube. The rough irregular line of junction between the inferior and internal aspects of the petrous bone gives origin to the *levator palati* muscles and to the pharyngeal aponeurosis.

Other structural details of the petrous bone are described in connection with the anatomy of the ear (§ 537).

Development.—The whole squamous portion ossifies from a single centre, appearing near the root of the zygoma in the seventh week. The styloid portion

by growing outwards, lengthen the meatus, and at the end of the second year they meet externally, bounding a foramen in the bony floor of the meatus, which gradually closes, disappearing at six. The hiatus subarcuatus, which represents the floccular fossa of other mammals, is large in the fetal bone, and in early life transmits a minute vessel. The mastoid process begins to project at the end of the first year.

At birth there is an air-space beneath the hinder edge of the squamosal, where it overlaps the mastoid portion. This is the mastoid antrum, and it opens into the tympanum. The walls of this cavity thicken, become cancellous, and are finally absorbed, and air-spaces invade the cancellous tissue at about nine years of age.

Small ossicles (the **bones of Riolo**) are frequently developed along the petro-occipital suture.

Besides the structures directly connected with the ear and lower jaw, the temporal bone in the recent state has attached to it a **petro-occipital ligament**, sometimes ossified into an intrajugular process, which traverses the jugular hole, separating the venous or posterior part of the foramen from the nervous or anterior part.

The temporal bone contains within it three sets of *cavities*:—1, The **tympanum**, at the bottom of the external auditory meatus, which, with the Eustachian tube, is the modified cavity of the first post-oral visceral cleft; 2, the **vestibule** and its appended cavities, the coiled cochlea in front, the semicircular canals above and internally; and 3, the **mastoid cells**, excavations in the surface and substance of the opisthotic, covered in by the squamosal.

The temporal bone gives origin to eleven muscles and insertion to three.

122. THE SPHENOID is a compound bone made by the fusion of ten elements, and forming part of the floor of the anterior and middle cranial fossæ, of the temporal and nasal fossæ, of the orbit and base of the skull. It consists of a median **body**, two **lesser wings**, and two **greater wings**.

The **body**, made by the union of two parts which represent the united pre- and basi-sphenoid bones of other vertebrates, presents six surfaces; its posterior aspect is rough, and unites with the basioccipital by synchondrosis before the age of twenty-one, but after that age by synostosis (fig. 326). Above this is the upper part of the **clivus** or anterior wall of the posterior cranial fossa, rising forwards to the **dorsum ephippii**. The sharp lateral margins of this portion slope downwards and outwards, and end in the sharp **processi petrosi postici**, which are joined by cartilage to the apices of the temporals.

The upper surface presents posteriorly the deep **pituitary fossa** or **sella turcica**, bounded behind by the rough-edged **dorsum ephippii**, which ends on each side in a lateral knob, the **posterior clinoid process**. In front of the fossa is the transverse **olivary process** or tubercle, anterior to which is the transverse groove for the optic commissure. This groove is bordered in front by a ridge, **limbus sphenoidalis**, from which a flat surface, **jugum sphenoidale**, extends forwards, forming part of the floor of the anterior fossa, ending anteriorly in the sharp **ethmoidal spine** which joins the hinder edge of the cribriform plate. From each side of this **presphenoidal surface** the lesser wings extend outwards.

The anterior surface presents a median sharp ridge, the **crista sphenoidalis**, descending from the under surface of the ethmoidal spine. The body of the sphenoid is seen in this aspect to be hollow, the cavity being divided by a median partition into two lateral parts, the **sphenoidal sinuses**. The **septum**, which is the backward continuation of the crista, is usually bent to one side. The opening of each sinus is bounded below and internally by a curved triangular plate of bone concave above, convex downwards and forwards, the **cornua sphenoidalia** (spheno-turbinals or ossicula Bertini),

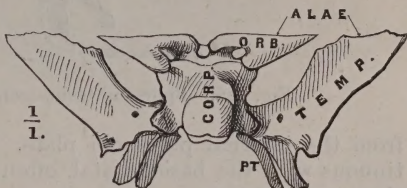


Fig. 325.—Sphenoid bone at birth, showing its component parts.

which are originally separate bones in the adolescent skull. External to the opening of the sinus is the vertical orbital lamella of the body of the sphenoid, which joins the hinder edge of the os planum of the ethmoid and presents below a palatine notch for the orbital plate of the palatine bone.

The lower surface forms the roof of the choanae and presents medially a ridge, the **rostrum**, continued down from the **crista**, sharp in front, shading off behind, and articulating with the vomer. On each side of this the inferior and posterior angle of the ossiculum Bertini is continued backward; external to which is a groove filled with thickened periosteum and bordered externally by a prominent lamella, **processus vaginalis**, continued inwards

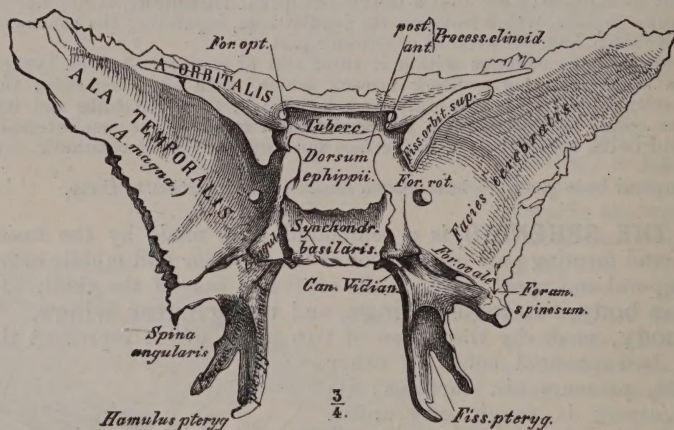


Fig. 326.—Sphenoid bone, seen from behind; its intracranial surface.

from the internal pterygoid plate. Behind these the sphenoid becomes continuous with the basioccipital, often presenting a median **foramen basillare** close to the suture.

The side of the body of the sphenoid gives attachment above and in front to the **lesser wing**, which has two roots—a superior, continuous with the upper surface of the body, and a lower on the level of the olivary process. Between these roots is the **optic foramen**, transmitting the optic nerve and the ophthalmic artery.

Below the lesser wing the side of the body bounds the **sphenoidal fissure** (superior orbital fissure) internally, and still farther downwards and backwards gives origin to the great wing. Above the root of the latter the side of the body is grooved by the carotid artery, the sulcus for which lies outside the olivary process, on each side of the pituitary fossa, and still more deeply indents the side of the body posterior to the root of the great wing. The lip of the groove behind the artery is the **processus petrosus posticus**; the thin lamella in front is the **ligula** or **processus petrosus anticus**—it really belongs to the body, but is pressed out by the artery and applied to the back of the great wing.

Three canals traverse the root of attachment of the great wing of the sphenoid along the outer side of the body—the uppermost is the **foramen rotundum** for the superior maxillary nerve, directly below the sphenoidal fissure; the second is the **Vesalian canal**, an irregular vascular hole, often absent, transmitting a small vein; the third or **Vidian canal** traverses the line of attachment of the internal pterygoid plate to the side of the body, and transmits the Vidian artery and nerve.

The **lesser wings** or orbito-sphenoids are elongated and triangular, projecting from the sides of the upper and anterior part of the body. They are flat above where they form part of the floor of the anterior cranial fossa. The front border is toothed to unite with the orbital plate of the frontal. The hinder edge is free and crescentic, and corresponds to the Sylvian fissure in the brain, ending posteriorly and internally in a sharp knob, the **anterior clinoid process**, which is directed towards the sella turcica, and often grooved on its inner side by the ophthalmic artery. The lower or orbital surface is smaller than the upper, and presents a sharp orbital ridge continuous with the front edge of the inferior root of the wing. From the periosteum clothing this ridge and the lesser wing, five of the orbital muscles arise. The apex of the wing is external, separated from the great wing by a narrow slit, closed in the skull by the orbital process of the frontal.

The **greater wings** or alisphenoids project from the lower part of the side of the body. Each presents four surfaces—a concave superior or cerebral, forming the front part of the floor of the middle cranial fossa; a quadrate flat

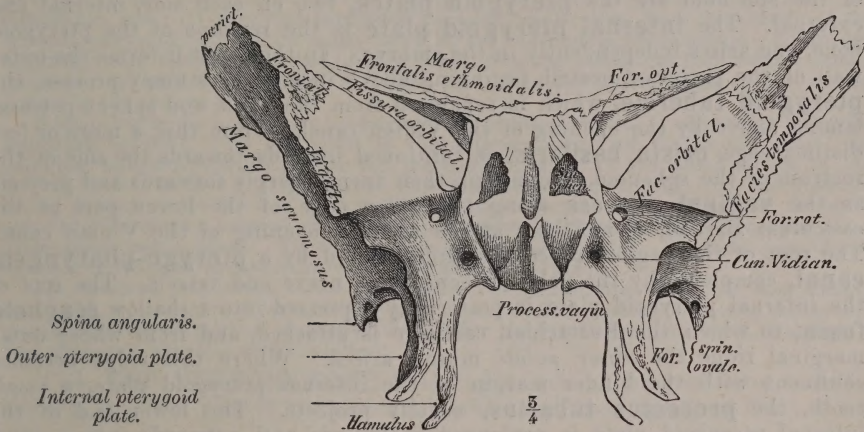


Fig. 327.—Sphenoid bone, seen from before; its basilar and orbital surfaces.

anterior or orbital surface making the chief part of the outer wall of the orbit; a convex external or temporo-basilar, and a triangular frontal or sutural surface which in the skull is covered by the orbital plate of the frontal.

The cerebral surface is isolated by four edges—an internal, sharp edge, which forms the outer lip of the sphenoidal fissure; a superior which enters into suture with the frontal and parietal bones; an external, concave, thicker behind, which articulates with the squamous; and a posterior, straight edge, joined by synchondrosis to the petrous. The external and posterior edges unite at the acute and back-directed **spine of the sphenoid**, which is pierced by a hole (**foramen spinosum**) for the middle meningeal artery. The outer part of the surface is grooved by branches of the middle meningeal artery, and by the inferior and middle temporo-sphenoidal convolutions of the brain. At its root are the **round** and **Vesalian holes**, behind and external to which is the **foramen ovale** for the inferior maxillary nerve. The thin plate of bone which bounds this behind (**lamina sphenopetrosa**) is often pierced by a fine **innominate canal**, for the lesser superficial petrosal nerve.

The flat orbital surface, whose plane converges backwards to that of its fellow at an angle of 100° , is bounded externally by a toothed edge, **crista malaris**, which joins the malar, above by a sutural edge for the frontal, below

its edge is rounded, and forms the hinder lip of the sphenomaxillary fissure, **crista sphenomaxillaris**, and internally its sharp edge forms the free margin of the sphenoidal fissure, **crista orbitalis**. A little in front of this is a tubercle for the attachment of part of the *external rectus oculi* muscle.

The temporo-basilar surface presents three parts—temporal, infra-temporal, and pterygoid. The horizontal **infra-temporal crest** limits the temporal area below, and enlarges anteriorly into a prominent knob, the **tuberculum spinosum**. The temporal portion gives origin to the *temporal* muscle, is bounded in front by the **crista malaris**; above, it articulates with the parietal and frontal bones; behind, it is overlapped by the squamous bone. The infra-temporal surface is bounded in front by the sphenomaxillary crest, and externally articulates with the squamous; it gives attachment to a few upper fibres of the *external pterygoid*, and at its hinder border presents the openings of the foramina ovale and spinosum. The lower surface of the spine of the sphenoid is usually elongated downwards into a **styloid process** or *spina angularis*.

Projecting downwards from the lower surface of the root of the great wing of the sphenoid are the **pterygoid plates**, two on each side, internal and external. The **internal pterygoid plate** is the remains of the pterygoid bone, and arises independently in the embryo. In the adult it forms the outer wall of the posterior nostril, beginning above in a small stumpy process, the **pterygoid tubercle**, which is separated from the ligula and sphenopetrosal lamina above by the opening of the Vidian canal. From this, a more or less distinct edge, **crista basilaris**, is continued inwards towards the side of the rostrum of the sphenoid, the margin then turns sharply forwards and projects as the **vaginal process** along the outer edge of the lower part of the ossiculum Bertini, terminating at the anterior opening of the Vidian canal. The root of the vaginal process is often pierced by a **pterygo-pharyngeal canal**, completed by the palatine bone, for a nerve and vessels. The root of the internal pterygoid plate is posteriorly depressed into a shallow **scaphoid fossa**, to which the Eustachian cartilage is attached, and from whose outer marginal ridge the *tensor palati* muscle arises. Where this ridge becomes confluent with the hinder margin of the internal pterygoid plate, a small tooth, the **processus tubarius**, usually projects. The lower end of the internal pterygoid plate is prolonged backwards and outwards into a spur, the **hamular process**, whose outer grooved surface (**sulcus hamuli**) forms a pulley for the tendon of the *tensor palati*. Between the two pterygoid plates below is a triangular interspace, into which the **pyramidal process** of the palatine bone is wedged. From the hamular process and lower half of the hinder edge of the internal pterygoid plate the *superior constrictor of the pharynx* arises.

The **outer pterygoid plate** is a muscular crest of the alisphenoid, and projects farther back, but not so low down as the inner. To its outer surface is attached the *external pterygoid* muscle, to its inner surface the *internal pterygoid*. These surfaces are rough for the attachment of tendinous planes in these muscles. The fossa between the two pterygoid plates is the **pterygoid fossa**.

Development.—The sphenoid bone is developed in the basi-cranial cartilage. About the eighth week a bony centre for the alisphenoid appears at the root of the great wing, a week later two unsymmetrical nuclei appear in the middle of the cartilage in front of the end of the notochord; these unite about the fifteenth week, forming the basisphenoid. About the ninth week bony formation begins in the orbitosphenoids directly outside the optic nerves, and in the eleventh week two nuclei form internal to these nerves, and rapidly extend outwards to unite with the orbitosphenoids, but they spread slowly inwards. These two pre-orbitosphenoidal ossicles join the basisphenoid at the end of the seventh month. The pterygoid bone shows its first sign of ossification in an ectosteal spot about the fifteenth week, and unites with the alisphenoid in the fifth month. The alisphenoids join the

basisphenoid ten months after birth. Accessory centres appear in the ligulæ about the sixth month, in the cornua Bertini in the first year, and these last join the body at sixteen. The cornua are at first solid cartilaginous blocks below the presphenoid and above the base of the vomer; but they become hollowed as they ossify, each being invaded at about seven years of age by a pouch of nasal mucous membrane, forming the sphenoidal sinus, under which ectosteal ossification progresses. The outer layer of the ossicle fuses with the root of the alisphenoid to form the roof-plate of the spheuo-palatine notch, the inferior part remains as the cornu as seen in the adult, while the upper portion rises and remains either as a horizontal partition, separating the sinus from the later formed spheuo-ethmoidal cells, which develop above it, or else it becomes absorbed. In old bones the sphenoidal sinus is often extended to the roots of the pterygoid plates. The dorsum ephippii is an independent ossification in the fibrous tissues underlying the dura mater.

The sphenoid bone thus presents forty named processes and ridges, is traversed by sixteen foramina, and forms part of the boundary of ten others. It gives attachment to thirteen pairs of muscles, and has originated from fourteen centres of ossification.

123. PROPER LIGAMENTS.—To the recent sphenoid bone four pairs of proper ligaments are attached: (1) **pterygo-spinous**, usually consisting of two slips, an upper and lower, from the styloid elongation of the spine of the sphenoid to the toothed hinder edge of the external pterygoid plate. Both this and the external pterygoid plates are specialised parts of a fibrous lamella developed between the planes of the two pterygoid muscles in the mandibular arch; (2) **pterygo-temporal**, a weak areolar slip, from the outside of the external pterygoid plate at its upper third to the tuberculum sphenoidum; (3) **inter-clinoid**, a cord included in a fold of dura mater, from the anterior to the posterior clinoid processes; (4) **carotico-clinoid**, a similar cord, from the lateral angle of the olivary process to the anterior clinoid.

Fibrous bands also exist, tying the petrous bone to the sphenoid. (1) **Anterior spheo-petrosal** ligament, from the ligula to the anterior margin of the carotid canal; (2) **inferior spheo-petrosal**, from the pterygoid tubercle to the under surface of the petrous bone at its apex; (3) **posterior superior spheo-petrosal**, from the posterior clinoid process to the front of the superior margin of the petrous, arching over the sixth nerve and the inferior petrosal sinus; (4) a **posterior inferior spheo-petrosal** sometimes exists below these. These ligaments occasionally ossify. The spino-mandibular ligament is described in connection with the lower jaw (§ 134).

The detached post-frontal ossicle in the spheo-parietal suture, which has been already mentioned, is a membrane bone, arising as a cluster of little osseous nodules in the seventh month, and has no original connexion with either the orbito- or alisphenoid, although it may ultimately ankylose with the latter.

124. THE ETHMOID BONE is a fragile cubical mass of bony lamellæ, making the chief part of the skeleton of the nasal fossæ, lying in front of the

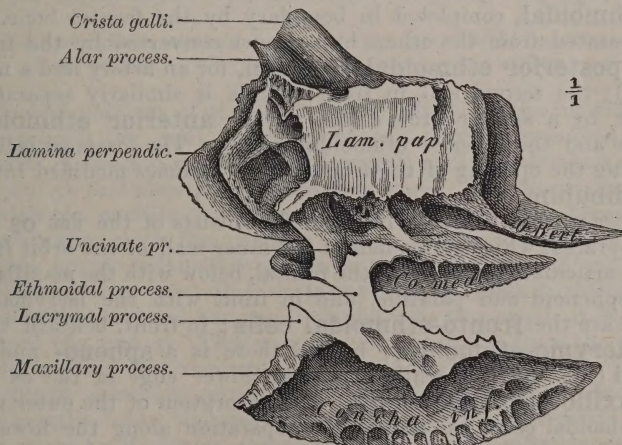


Fig. 328.—Ethmoid and inferior turbinal bones seen from the left side.

body of the sphenoid below the ethmoidal notch of the frontal. It consists of four parts: (1) A small horizontal **cribriform plate** (fig. 312), which fills the

ethmoidal notch of the frontal; from the middle line of which projects upwards (2) a spur, the **crista galli**, and downwards (3) a thin median plate, the **lamina perpendicularis**, making the upper third of the septum between the right and left nasal passages. (4) From the lateral border of the cribriform plate on each side descends an irregular mass of thin-walled bony cells (the **nasal labyrinth**), presenting a flat plate, the **os planum** (*lamina papyracea*—fig. 308), outwards towards the orbit, and an irregularly folded surface inwards, which forms part of the outer wall of the nasal fossæ (fig. 309).

The **cribriform plate** is thin and depressed, and pierced by three irregular rows of holes, from twenty to thirty on each side, for branches of the olfactory nerve. The outer holes transmit branches to the labyrinth, the middle to the roof of the nose, and the inner to the septum. On each side of the **crista galli** is a slit for the nasal branch of the fifth nerve.

The **crista galli** (fig. 312), thin behind, rises forwards into a thick triangular process which gives attachment to the *falx cerebri* of the *dura mater*, and ends in front by descending rather suddenly to the **foramen cæcum**, on each side of which it sends an **alar process** forward.

The **lamina perpendicularis**, or *mesethmoid* (fig. 310, F), is a five-sided plate attached above to the cribriform plate, through which it is continuous with the **crista galli**. Its surfaces along this border are grooved, pierced, and channelled by the descending nerves. Above and in front it descends from the *processi alares* beneath and attached to the nasal spine of the frontal (fig. 309), and underlies the median union of the nasals for a short extent. Below and in front it presents a retreating border, thickening where it becomes continuous with the cartilaginous element of the nasal septum. Below and behind it articulates with the vomer, which is here thin; posteriorly it joins the **crista sphenoidalis**. In the recent state its periosteum is inseparable from the mucous membrane which covers it.

The **labyrinth** or lateral mass originally presented a continuous wall bounding its contained cells, but as age advances this has become absorbed wherever it underlies other bones, and so the cells open on the surface. Its upper surface rises above the level of the cribriform plate (fig. 310, 2) and underlies the orbital plate of the frontal; the cells along this surface are **fronto-ethmoidal**, completed in boundary by the frontal bone. The hindmost is separated from the others by a groove converted by the frontal into a canal, the **posterior ethmoidal foramen**, for an artery and a minute nerve (fig. 308, 6); the second cell in front of this is similarly separated from its predecessor by a similar groove (*ib.*, 5), the **anterior ethmoidal**, for the nasal nerve and the anterior ethmoidal artery. The foremost cell underlying and receiving the opening of the frontal sinus becomes modified into a passage, the **infundibulum**.

The outer wall of the labyrinth chiefly consists of the flat **os planum** or *lamina papyracea*, which forms half of the inner wall of the orbit (figs. 307 and 308). This articulates above with the frontal, below with the maxilla, posteriorly with the sphenoid and palatine, and in front with the lacrymal; along its upper edge are the **fronto-ethmoidal cells**; in front, beneath the lacrymal, are two **lacrymo-ethmoidal**; behind there is a **spheno-** and a **palato-ethmoidal** (fig. 308, 6); while along the lower edge of the **os planum** are several **maxillo-ethmoidal cells**. The absorption of the outer wall of these maxillo-ethmoidal cells has caused the separation along the lower and outer border of a slender irregular slip, the **processus uncinatus** (fig. 309, 6), attached in front, free behind and below, which articulates below with the inferior turbinal. Above and in front of this there may be a second or **lesser uncinate process**.

Each ethmoidal cell opens into the nasal cavity between the labyrinth and

the mesethmoid. The hindmost fronto-ethmoidal cells bulge the inner wall of the labyrinth inwards above, and this projection is continued downwards as a sharp curved fold, the **superior turbinal bone**, which overlaps the mouths of the cells. Above and behind this, the openings of the sphenoidal and sphenoid-ethmoidal cells form a depression, the **meatus supremus**, over which there is sometimes a small curved bony plate, the **concha suprema**. The maxillo-ethmoidal and anterior fronto-ethmoidal cells similarly bulge inwards, and from their borders a shell-like lamella, the **middle turbinal bone**, is continued downwards, forming a lower boundary for the space between it and the superior turbinal, which is called the **superior meatus** (fig. 309, 2), and roofing a second space, the **middle meatus** (*ib.*, 6), from which openings pass into the large air-space of the upper jaw (7), the anterior ethmoidal cells, and through the foremost of these, or infundibulum, into the frontal sinus.

The ethmoid ossifies in the cartilage of the nasal capsule. A small centre appears on each side in the inner wall of the orbit about the seventeenth week, which gives rise to the os planum and extends outwards into the labyrinth and causes its ossification. Six months after birth a single nucleus appears in the mesethmoid which spreads into the crista galli, cribriform and perpendicular plates. The first traces of ethmoidal cells appear as rudiments in the seventh month fetus, but true bony cells do not develop until the end of the third year. The ossification of the cribriform plate unites the lateral mass to the mesethmoid at the beginning of the third year.

The ethmoid thus articulates with thirteen bones, has fifteen named processes and lamellæ, is traversed by the many foramina of the cribriform plate, assists in bounding ten other foramina, ossifies from three centres, and gives attachment to no muscles.

125. THE INFERIOR TURBINALS are a pair of thin curved lamellæ, one on each side, separating the middle from the inferior nasal (fig. 309, 9) meatus.



Fig. 329.—Right inferior turbinal bone, inner surface.



Fig. 330.—Right nasal bone, posterior surface.

They are detached portions of the ethmoid articulated to the inferior border of the uncinæ process (fig. 328). Each presents a slightly crumpled inner side whose convexity is directed upwards and inwards, ending below in a convex free border (fig. 329, 5), and above in its attached edge. Its sharp anterior angle articulates with the maxilla (fig. 329, 2), and its longer, more tapering hinder extremity articulates with the palatine (*ib.*, 1). Between these on the outer face of the bone are three lamellar processes, two ascending and one descending (fig. 328). The anterior ascending or **lacrymal process** turns upwards and forwards to join the lacrymal bone and complete the tear canal; it is the highest part of the bone (fig. 329, 3). This is separated by a notch from the **ethmoidal process** which joins the uncinæ process of the ethmoid (*ib.*, 4). A flat **maxillary plate** descends vertically at the middle third of its outer side, lying on the maxilla below the opening into the maxillary air-cavity or antrum. The inferior curved side forms the upper wall of the inferior meatus. The vascular marks upon this bone are sagittally directed (fig. 308, 18).

This bone ossifies in cartilage at the fifth month and has attained to its adult shape at birth, it attains its full size at seven years of age and ankyloses to the ethmoid at twenty. It assists in bounding two foramina, has six processes, and articulates with four bones.

126. THE NASAL BONES are two contiguous oblong strips whose shape determines the form of the nose. Their facial surface is concave forwards along the vertical axis, flat or convex transversely; and each presents a nasal foramen for a nasal tributary of the facial vein. Each bone articulates above with the frontal by a short convex surface beset with sharp cusps (fig. 330, 1); externally its longest edge is fitted into an irregular groove in the maxilla (*ib.*, 3); internally it meets its fellow in the middle line by a surface which is wide above, but which narrows to a thin edge below (*ib.*, 4). Posteriorly it rests above on the rough nasal process of the frontal (fig. 317), while below, the contiguous margins of the two nasal bones are prolonged inwards as a median ridge which rests on the mesethmoid; on each side of this, the concave nasal surface is lined by mucous membrane, and is grooved longitudinally by the nasal nerve and some small vessels (fig. 330, 6). The lower edge (*ib.*, 2) is



Fig. 331.—Left lacrymal bone, outer or orbital surface.

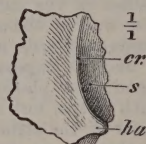


Fig. 332.—Right lacrymal bone, orbital surface, second form of the bone.

irregular and thin, prolonged into a shorter median and a longer lateral **nasal spine** between which is a **prenasal notch** for the exit of the cutaneous branch of the nasal nerve.

The nasal is an ossification in the membrane over the cartilaginous nasal sac, and begins to ossify in the seventh week. The underlying cartilage becomes absorbed before birth. The fetal bone is shorter and broader than the adult, and in the fifth month measures 5 mm. by 3; in the seventh, 7 by 4; in the ninth, 10 by 6; while the average male adult bone measures 25 by 12 at its broadest point, and 7 at its narrowest, which is near its upper point of trisection, the fundus of its curve. The bone is somewhat three-sided for its upper third, becoming flat and thin below. The outer edge is usually concave above, convex below. The inner usually presents a few well-marked cusps close to its frontal end.

The shape of the nose is modified by the depth of the fronto-nasal sulcus; this is absent in the hypothetical Greek profile, but deep when large frontal sinuses co-exist with nasal bones which are concave in their upper half. It also varies with the profile of the lower half of the inter-nasal suture, which is either straight or concave, as in the flattened or tip-tilted nose, or convex, as in the aquiline; or with the width of the nasal bones and the angle formed with each other by their facial surfaces, as well as with the relative sizes of the bones and cartilage.

127. THE LACRYMAL BONES are two thin, often fenestrated, somewhat quadrilateral scales, the smallest of the membrane bones of the face, each forming the front part of the inner wall of the orbit (fig. 308, 8). Its orbital surface presents a flat posterior or orbital area, and a sulcus lacrymalis anteriorly (figs. 331, 3; 332, s). The former articulates with the os planum behind, the frontal above, and the maxilla below, ending anteriorly in a sharp vertical **crista lacrymalis**, from which the **tensor tarsi** muscle arises, and whose lower end, or **hamulus** (figs. 331, 4; 332, ha), is prolonged forwards as a hook on the outer side of the nasal duct. The **sulcus lacrymalis** is a vertical groove, in front of the crest, for the lacrymal sac and nasal duct; it is usually pierced by many vascular holes, and joins the maxilla by a straight edge in front.

The slightly irregular inner or nasal surface lies on the ethmoid, completing two lacrymo-ethmoidal cells and part of the wall of the infundibulum. Its lower border ends in two lamellar processes, a roughly triangular **processus turbinalis**, which joins the lacrymal process of the inferior turbinal bone, and a **processus lacrymalis**, which forms the terminal concave lamella of the

sulcus lacrymalis. The front edge of the uncinatè process of the ethmoid articulates with the concave nasal side along the line of the crista (fig. 309, 8).

The lacrymal thus articulates with four bones, gives attachment to one muscle, and assists in forming two canals.

It ossifies in membrane over the lateral aspect of the olfactory capsule, and first appears in the eighth week close to the orbital plate of the maxilla. Its upper edge touches the frontal in the twelfth week, and the crista appears in the thirteenth, but the suture with the os planum does not appear until the sixth month, nor that with the inferior turbinal until the seventh.

At four months it measures 4 mm. in vertical height, at six months 5 mm., at birth 7·5 by 5, in the adult male 16·5, in the adult female 15·5. The investing periosteum is thin, and the bone generally contains no Haversian canals. Its vessels, derived from the infraorbital artery and nasal branch of the ophthalmic, ramify on its surface. The hamulus is the degenerated remains of the facial part of the lacrymal of lower mammals. The whole bone is a diminishing element.

128. THE VOMER is a single median vertical plate which forms the hinder and lower part of the nasal septum (fig. 310, G). Its posterior free edge is smooth and concave, and forms the partition between the posterior nares. The upper edge is the stoutest and thickest. It splits into two alæ which embrace between them the rostrum of the sphenoid, making therewith the typical schindylesis joint. The anterior margin is long and very oblique. Its upper half touches and ankyloses with the mesethmoid, while for its lower half it separates into two lamellæ, between which the lower margin of the septal cartilage is received. The inferior border reaches to and joins the septal crest which rises along the nasal surface of the median palatine suture of the maxillæ and palatine bones. The anterior angle is truncated, abutting on the elevated incisive crest of the premaxilla, and sending on its lower surface a small tongue of bone which divides into two the upper opening of the anterior palatine canal.

The vomer is clad on each surface with mucous membrane inseparable from the periosteum, and marked on each side by a faint groove sloping downwards and forwards for the naso-palatine nerve and vessels. It is usually unsymmetrical, pushed to one side, commonly to the left. It is a membrane ossification in the sheath of the mesethmoid cartilage, beginning by two lateral centres which appear in the seventh week. The young bone consists of two lamellæ which become early united below, hence it appears double along its upper, but single along its palatine edge.

The development of the nasal septum is an interesting morphological study. It is primarily a cartilaginous lamella whose upper and back parts ossify endosteally as the lamina perpendicularis of the ethmoid. The membranous sheath of its lower and back part ossifies, forming the vomer, while the cartilage which originally separated its layers undergoes atrophy. The anterior part persists in its original cartilaginous form.

The vomer articulates with six bones, has three named processes, one pair of grooves, and forms part of two pairs of foramina, the posterior nares and the anterior palatine.

In the region of its sphenoidal articulation there are three canals transmitting small vessels in the young skull, which usually become obliterated with advancing age; these are—one median vomerine canal between the vomer and the root of the rostrum, and a lateral on each side between the extremity of the ala vomeris and the vaginal process. These run parallel to and may communicate with the pterygo-pharyngeal canal in the vaginal process.

129. THE MALAR BONES are two hard bones uniting the zygomatic processes of the temporal to the facial bones, and forming the outer piers of the orbital arch. Each malar projects prominently in the face and separates the orbit from the temporal fossa. It consists of two lamellæ, facial and orbital, united together at an angle of 70° along the crescentic orbital margin, so as to present three surfaces—**facial, temporal and orbital**. The facial surface presents below its mid point an enlargement, the **malar tuberosity**, from which the *zygomatici, major* and *minor*, arise; above this is the opening of the zygomatico-facial canal (fig. 333, z). Its highest point, the **frontal process**, articulates with the external angular process of the frontal bone (fig. 307); from

this its posterior or temporal margin descends as a sharp sigmoid line (fig. 333), to which the temporal fascia is attached; a strong ascending slip of this fascia is attached to one spot of this border, which is occasionally lengthened into a **processus marginalis**. Below this edge is the **zygomatic angle** (*ib.*, *Jug.*), which joins the zygomatic process of the temporal in a bevelled suture, wherein the malar underlies the temporal. The inferior or masseteric edge is rough for the origin of the *masseter* muscle, and dilated into a tubercle at its anterior extremity, where it joins the malar process of the maxilla. The anterior or facial edge is a concave suture, joining the maxilla obliquely, its upper extremity stretching forwards and inwards to end in a sharp **infraorbital process**, whose edge forms more than half of the lower margin

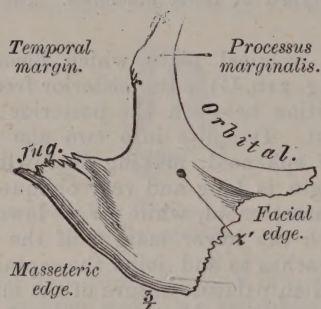


Fig. 333.—Right malar bone, outer or facial surface.

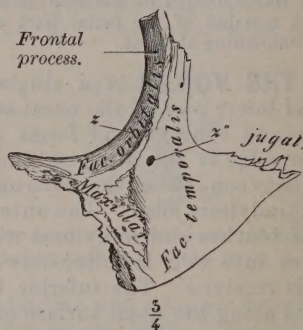


Fig. 334.—Right malar, inner or temporo-orbital surface.

of the orbit. The orbital edge is smooth and rounded, forming an arc of more than 120° , and making more than one-third of the circumference of the orbit.

The temporal or hinder surface is concave, pierced by the **zygomatico-temporal canal** (fig. 334, *z'*), giving origin to a few fibres of the *temporal* muscle, especially at the inside of its zygomatic angle, but mostly in contact with the buccal mass of fat. The back of the bone is horizontally crossed by a faint groove (*sulcus internus*) from the middle of the zygomatic suture to the middle of the maxillary suture, in which a thick band of periosteum lies, which may become ossified at either end. The inner margin of this surface articulates above with the frontal, next with the great wing of the sphenoid, and below with the maxilla. Between its line of articulation with the sphenoid and maxilla it closes the outer end of the sphenomaxillary fissure.

The orbital surface is concave, pierced by the orbital ends of the zygomatic canals (*ib.*, *z*).

The malar ossifies in membrane from two centres, one appearing in the seventh week near the orbital margin for the chief mass of the bone; a second, not always constant, for the lower margin, appearing as a nodule about the twelfth week, and joining the upper one about the sixteenth; a third occasionally, but inconstantly, occurs in the hinder edge, which appears about the thirteenth week, but joins in the sixteenth, so that the bone appears single at the end of the fourth month. The primary articulations of this bone are the zygomatic and maxillary, but the frontal, though secondary, becomes the most important in the adult, as by it the shock of the impact of the lower jaw on the upper is transmitted to the skull. This portion, therefore, becomes the strongest part of the bone.

The malar articulates with four bones, has seven named processes, gives origin to four muscles, and is pierced by three holes, while it forms a partial boundary of three others.

130. THE MAXILLÆ are irregular, hollow, and somewhat five-sided bones which form the largest part of the face, of the outer wall of the nose, the

roof of the mouth, and the floor of the orbits. Each bone meets its fellow along the middle line of the hard palate in the middle palatine suture; they also unite in a median suture for a short distance on the face, between the central incisor teeth and the nasal aperture. Its lowest border forms the **alveolar arch**, which in the adult makes a quadrant of an ellipse, and in which are implanted the fangs of eight teeth. The sockets are of hard bone, pierced by numerous closely set holes for vessels; their inner border is thicker than the outer, which is thin and margined by a faint ridge.

The facial surface, above the alveolar arch, presents two shallow fossæ, the **myrtiform**, above the incisor teeth, separated from the larger or **canine fossa** (fig. 355, 2) by a rounded **canine ridge** (*ib.*, 3), formed by the projection forwards of the socket for the canine tooth. From the myrtiform fossa arises the *depressor labii superioris muscle*, from the canine the *levator anguli oris* and the *compressor nasi*. This fossa is bounded behind by the **zygomatic ridge**, which starts from the alveolar arch at the socket for the first molar tooth. At its upper part is the **infraorbital foramen** (14), and externally is the **malar process** (11) for the malar bone. The upper and inner part of the facial surface is prolonged upwards between the nasal and lacrymal bones to articulate with the frontal. This **nasal process** (6) is marked by a vertical row of holes, the **sutura notha**, pierced by branches of the infraorbital artery, behind which the orbital margin is prolonged upwards as an **orbital ridge** (7), giving attachment to the *tendo oculi* and its associated fasciæ. Behind this ridge the nasal process forms the front wall of the lacrymal sulcus (8). The orbital ridge is continued outwards, and forms the upper limit of the facial surface as far as the

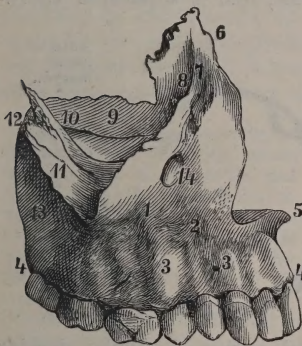


Fig. 335.—Right maxilla, outer and front surface.

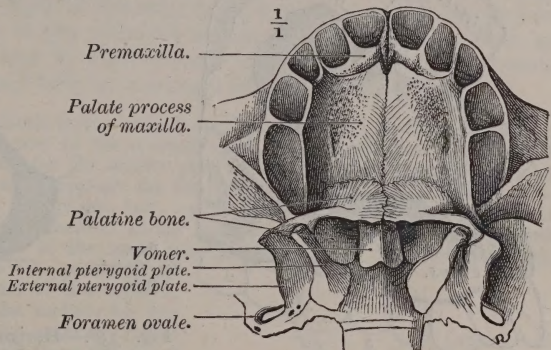


Fig. 336.—Palatine surface of maxilla and palatine bones from a child of one year old.

malar suture, and is often crossed by a small **sutura verticalis**, descending from it to the infraorbital foramen. The facial surface ends internally at the **apertura pyriformis** to the sharp edge of which the soft parts of the nose are attached; below, it projects in the middle line as the **nasal spine** (5), giving attachment to the columna nasi.

The flat orbital surface (9) slopes downwards and outwards, and is bounded in front by the short orbital ridge, behind which its inner margin is indented by the lacrymal sulcus, around which the hamulus of the lacrymal bone stretches. Behind this its inner edge articulates with the lacrymal and os planum, between which it sends a projecting spur (**angulus ethmo-lacrymalis**), and posteriorly its apex is truncated by a suture for the palatine bone (12). Externally it is separated by the sphenomaxillary fissure from the great wing of the sphenoid, and in front is overlapped by the infraorbital process of the

malar bone. The surface is marked sagittally by a groove behind, becoming a canal in front, the **infraorbital canal** (10), for a nerve and artery. Along the upper surface of its closed anterior part a sutural line, the **sutura infra-orbitalis**, is continued forwards to the sutura verticalis. When this canal is opened by filing off its roof two smaller canaliculi are seen to arise from it and to descend in the front of the maxilla to the sockets of the front teeth. Close behind the orbital margin and external to the hamulus lacrymalis is a pit giving origin to the *obliquus inferior oculi*.

The rough and rounded hinder surface, or **tuber maxillare** (13), extends from the back of the alveolar arch behind the zygomatic ridge upwards to the sphenomaxillary fissure, whose edge is here grooved by the beginning of the infra-orbital canal. Externally it is continued into the malar process on which the zygomatic ridge is prolonged from below to end in a **masseteric tubercle**. Above, the malar process ends in two spurs, one the **zygomatic spine** which juts backwards indenting the malar at the front end of the sulcus internus. The second, or **sphenoidal spine**, ascends in front of the sphenomaxillary fissure towards the sphenoid, but it is usually separated from that bone by the interjection of a small spur of the malar. At the upper and inner extremity of this surface where it meets the orbital and nasal surfaces is a rough area, **trigonum**

palatinum (fig. 337, *pa*), upon which lies the palatine bone. The tuber is grooved and pierced by the branches of the posterior superior dental nerve and artery. The inner edge of this surface runs along the front of the pterygoid plates, but is separated there-



Fig. 337.—Right maxilla, seen from within.

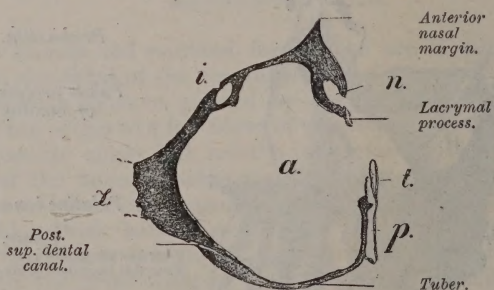


Fig. 338.—Horizontal section of maxilla, showing the antrum—*i*, infraorbital canal; *n*, nasal duct; *p*, palatine bone; *t*, inferior turbinal; *z*, zygomatic process of maxilla.

from by a thin lamella of the palatine bone. It is interesting to note that the edge of the maxilla pursues that of the sphenoid, but seldom touches it as the malar and palatine intervene.

The inferior surface of the maxilla consists of the alveolar arch with the hard palate (**processus palatinus**) internal to it. The latter is concave, marked by irregular longitudinal ridges, and pierced by many holes and by an oblique **posterior palatine groove** running from behind forwards and inwards. Posteriorly is the transverse **posterior palatine suture** where it is joined by the palatine bone, internally is the **middle palatine suture** running sagittally between this bone and its fellow. Anteriorly behind the incisor teeth is a groove which, when the two maxillæ are in place, forms with its neighbour a central pit, the **anterior palatine canal**, from which two openings, the **canals of Stenson**, right and left, ascend to open into the two

corresponding nostrils. Two smaller holes, **canals of Scarpa**, traverse the suture in front and behind the canals of Stenson and transmit fine nerves. From this pit an imperfect **anterior palatine** or **premaxillary suture** can be traced outwards to the inside of the alveolus for the canine tooth.

The nasal surface of the maxilla is deeply concave and smooth below, where it forms the floor and outer wall of the inferior meatus. Along the median line below (fig. 337) it rises into a **semicrista nasalis** which, with its fellow, receives and articulates with the vomer, rising in front of the anterior palatine canal into a more prominent **semicrista incisiva**. Above the smooth area on the outer wall anteriorly is a horizontal **crista turbinalis** with which the inferior turbinal bone articulates, behind which is the **lunula lacrymalis** which forms part of the wall of the tear-duct. Behind this is the opening into the great central hollow of the bone, the **antrum of Highmore**. Still farther back the bone is rough and covered by the perpendicular plate of the palatine. At the back of this area is a deep descending groove which, with a similar groove in the palatine bone, forms the **posterior palatine canal**. The inner surface of the nasal process completes the anterior maxillo-ethmoidal cells and is marked by an oblique line, the **crista ethmoidalis**.

The **antrum** or *sinus maxillaris* (figs. 337; 338, *a*) is an irregularly four-sided cavity, occupying the interior of the bone whose substance is attenuated around it into thin walls, orbital above, facial in front, tuberosus behind, and nasal, the most extensive, internally. Its lowest part is in the interspace between the first and second molar teeth, and its lower border corresponds to the upper part of the alveolar arch behind the first premolar tooth, the bottom of the sockets projecting as hillocks along its lower angle. The large opening in the maxilla by which it communicates with the nose is encroached upon by the uncinate process of the ethmoid above, by the palatine behind, by the inferior turbinal below, and by the lacrymal in front. In the recent state it is diminished to a very small hole by a margin of mucous membrane.

The maxilla develops by parostosis in the united maxillary lobe and fronto-nasal process (§ 15). Three ossifying points appear in the seventh week, one for the facial surface, one for the floor of the orbit, and one for the hinder part of what is to become the alveolar arch. A week later a fourth centre appears for the palate process, and a fifth for the premaxillary element. All these, except the last, coalesce before the ninth week into an irregular bony mass, which is supplemented at the beginning of the ninth week by two accessory centres, one for the back of the nasal process, and one for the malar process; these also unite speedily. From the premaxillary centre in man, the portion in front of the canal of Stenson, and the hinder wall of the sockets for the incisor teeth are developed, but the anterior wall of the sockets of these teeth is formed from the facial part of the maxilla, hence no premaxillo maxillary suture ever normally appears on the human face as it does in other mammals, but the suture between these elements on the palate persists until middle life. When, from deficiencies of the front of the maxilla, the premaxillary elements fail to unite with the rest of the maxilla, it constitutes the separate premaxillary bone which so often co-exists with double harelip.

In the course of growth the alveolar process extends around the tooth-germs which originate in the mucous membrane; at first an inner, then an outer wall descend, and include between them a long continuous dental groove, partitions between the teeth (*juga alveolaria*) being later in development. The premaxilla often appears double in its early stage as it includes two alveoli. The antrum originates at the beginning of the fourth month as a shallow pouch of the cartilaginous outer wall of the nasal capsule, projecting outwards between the places where afterwards the ethmoid and the inferior turbinals are formed. As this pouch enlarges its cartilage disappears (fig. 339), but the cavity does not assume its full growth until after the second dentition. In the third month the infraorbital

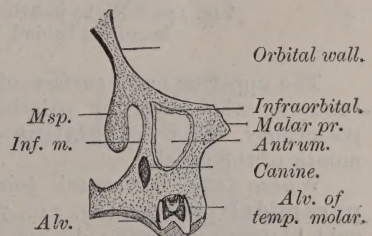


Fig. 339. — Coronal section of left maxilla at birth, showing antrum.

nerve lies in a groove in the orbital plate, but a lamella from the malar process of the maxilla overlaps it at the orbital brim, either fusing with, or uniting in a suture with the inner portion. This groove at first lies external to the antrum but, after the first dentition has commenced, the antrum extends beneath the groove.

The maxilla articulates with nine bones, presents eighteen named processes and ridges, is pierced by one foramen, forms a partial boundary of five others, and gives attachment to nine muscles, while it originates from seven centres of ossification.

131. THE PALATINE BONES are two thin irregular L-shaped bones, each consisting of two lamellæ—one vertical applied to the back of the maxilla where it approaches the pterygoid plates (fig. 340, 3), and one horizontal, the **palate process**, which forms the hinder part of the hard palate (*ib.*, 5). This portion is quadrate, presenting a concave free border behind, to which the soft palate is attached, and which forms the lower edge of the choanæ. This combines with its fellow medially to form the back-jutting **posterior nasal spine** (fig. 311), from which the *motor uvulæ* arises. Internally it joins the corresponding bone of the other side in the middle palatine suture, along the upper surface of which is a **semicrista nasalis** (*ib.*, 6), which with its fellow articulates with the vomer (fig. 310). Anteriorly it joins the palate process of the maxilla in the posterior palatine suture, externally it presents a deep notch (fig. 341, 8), completed by the contiguous border of the maxilla into the **posterior palatine canal** (fig. 311).

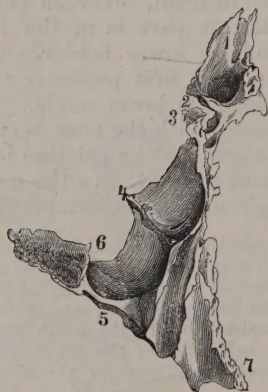


Fig. 340.—Right palatine bone, seen from behind.

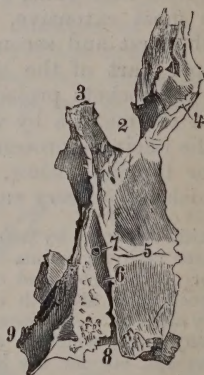


Fig. 341.—Right palatine bone, external view.

The upper or nasal surface of the palate process is smooth and transversely concave; the lower or palatine surface is marked by a transverse ridge posteriorly, and by a **palatine groove** laterally, stretching forward from the mouth of the canal.

Where the horizontal joins the perpendicular plate, a wedge-shaped **pyramidal process** (fig. 340, 7) projects backwards between the two pterygoid plates, completing, by its hinder concave surface (fig. 311), the floor of the pterygoid fossa. The inner side of the process receives the front of the internal pterygoid plate into a groove, the outer is expanded as a lamella on the external plate.

Two fine **accessory palatine canals** run through this process at its root, branching off from the larger posterior canal. From its tuberos lower end a tendinous slip of the *internal pterygoid* muscle arises.

The perpendicular plate ascends in contact with the hinder part of the inner surface of the maxilla, with its posterior margin applied to the front edge of the pterygoid plates, from which it is separated above by the canal

for the posterior palatine nerve and vessels. Its inner surface (fig. 340) is turned towards the nasal fossæ, and is crossed by two transverse lines, the **crista turbinalis** below for the inferior turbinal bone (*ib.*, 4), and the **crista ethmoidalis** above for the ethmoid (3). Between and below these the bone is smooth and mucosa-clad in the recent state. The external rough surface (fig. 341) is applied to the maxilla, and by its front edge it overlaps the mouth of the antrum, while along its hinder edge the posterior palatine groove is continued, and above it, over the crista ethmoidalis the upper extremity of this plate is divided into two processes, **orbital** and **sphenoidal**. The former (*ib.*, 4) is five-sided, and is the larger, higher, and farther forward, hollowed to form the outer wall of a **palato-ethmoidal cell** whose mouth looks inwards and whose edges join the contiguous edges of the ethmoid. Its front surface overlies the hinder surface of the maxilla, and its upper and inner edge touches the orbital side of the body of the sphenoid. This process has two free surfaces—one flat, oblique, and triangular, the orbital; the other more irregular bounds the spheno-maxillary fissure on its anterior and internal side.

The posterior or **sphenoidal process** (fig. 341, 3) is smaller, less prominent, and bent more directly inwards beneath the body of the sphenoid. Its inner surface is directed to the nasal fossæ, its outer forms part of the floor of the pterygo-maxillary fossa, and touches the body of the sphenoid above, completing the front part of the pterygo-palatine canal.

Between these processes is a deep notch, completed into the **spheno-palatine foramen** by the smooth area of the root of the great wing of the sphenoid between the round and the Vidian foramina, and by an outward extension of the cornu sphenoidale.

The palatine bone is formed in a part of the pterygo-quadrate cartilage, and is very irregular and variable. It ossifies by a single centre which appears at the front of the pyramidal process in the seventh week.

It articulates with six bones, gives attachment to five muscles, is traversed by two foramina and forms part of the boundary of four others, and presents nine named processes.

132. THE MANDIBLE is the largest, hardest, and heaviest bone of the face, of whose lower third it forms the skeleton. It consists of a horse-shoe-

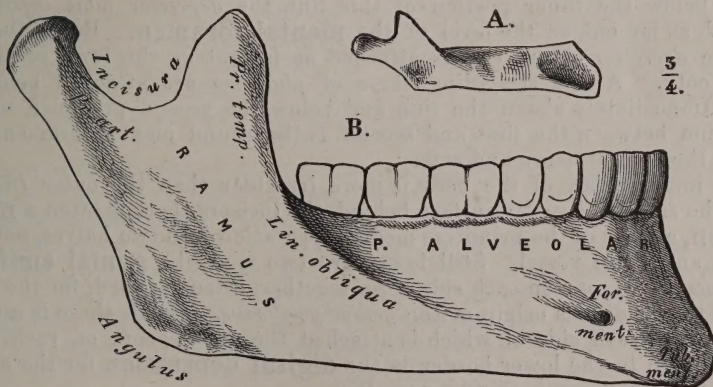


Fig. 342.—Side view of mandible—A, of infant at birth; B, of adult.

shaped body, which on each side rises into an **ascending ramus**, ending above in two processes. The body is made up of two symmetrical halves whose union in the middle line is called the **symphysis menti** (fig. 342). The upper edge of the body forms a parabolic curve, and is named the

alveolar arch, as it is excavated into a row of pits for the reception of the teeth. Along the convex side the several sockets often bulge to form appreciable swellings, while along the concave side the bone is uniform, thicker, and often raised into an obscure roughish seam.

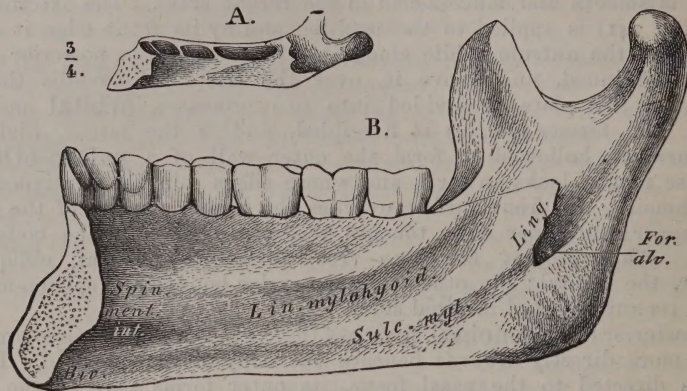


Fig. 343.—Half of mandible seen from within—A, of infant at birth ; B, of adult.

In the middle line the front of the body presents traces of an obscure vertical symphyseal line, and the lower border here projects forwards as a broadly triangular or rounded process, the chin or **mental process**, whose base below is rounded, often marked with a shallow median notch, on each side of which is a blunt swelling, the **mental tubercle**, from whose upper surface a faint line, which forms the limit of the mental process, ascends to meet its fellow in the middle line below the sockets of the incisor teeth. Outside this line and above the tubercle is the **fossula mentalis**, which gives origin to the *levator menti*.

From the outer angle of the mental tubercle a faint interrupted **external oblique line** ascends backwards to the level of the last molar tooth. Immediately below the inner portion of this line the *depressor labii inferioris* is attached, as far out as the level of the **mental foramen**. Below the outer part the *depressor anguli oris* is attached as far out as the level of the first molar tooth. A few straggling fibres of *platysma* are attached below this level. Immediately above the line and below the second premolar tooth, or the jugum between the first and second, is the round mental foramen, transmitting the mental nerve and artery.

The inner surface of the body is more irregular than the outer (fig. 343). Below the smooth alveolar surface behind the incisors there is often a **median foramen**, a trace of the primitive median separation into two halves, not transmitting any large vessel. Still lower are two spur-like **genial eminences** (*Spin. ment. int.*), one on each side close together, often blended, for the attachment of the tendinous origin of the *genio-hyo-glossus*. Below these is a median roughness, to each side of which is attached the *genio-hyoid*; on each side of this and close to the lower border is the **digital depression** for the anterior belly of the *digastric* muscle (fig. 343, *Biv.*).

Above and outside the digastric area the **linea obliqua interna** begins, stronger and more distinct than the external, ascending in the same direction to the ramus, which it reaches on the level of the last molar tooth. To this line is attached the tendinous origin of the *mylo-hyoid* and, for its hinder fifth, the *mylo-pharyngeus*. Above it is a shallow depression for the sublingual gland, between which and the teeth is a rougher surface for the attachment of the

mucous membrane of the mouth continuous into the gums above. Below the line is a depression for the submaxillary gland, under which the margin of the bone is smooth and subcutaneous, often grooved for the facial artery.

Each **ramus** is a quadrilateral, flat ascending process, including all that portion of the bone behind the alveolar arch. The inferior edge of the body is continuous with that of the ramus, and where this margin ends posteriorly by turning sharply upwards it makes the **angle of the jaw**. This angle is usually rough, obtuse, and a little everted, measuring in the adult male about 122° . The hinder edge of the ramus is thin and of very compact bone; its lower half gives attachment to a strong fascial fold, the stylomandibular ligament. Above this it is rounded and overlapped externally by a lobule of the parotid, finally expanding into the articular **condyle**. This margin is nearly vertical when the mouth is shut.

The outer surface of the ramus is slightly concave below, owing to the eversion of its lower and hinder edge, where it presents a row of irregular tubercles for the attachment of the tendinous planes in the *masseter* muscle. The anterior edge of the outer surface is thin and sigmoid

in outline, the continuation of the external oblique line.

The inner surface of the ramus presents below a rough surface at the angle, marked by three or four oblique irregular lines directed downwards and outwards for the tendinous planes in the *internal pterygoid* muscle, corresponding on the inner side to those for the attachment of the masseter on the outer surface. Above this is a large hole, the **foramen mandibulare**, for the inferior dental nerve and artery. From this the mandibular canal descends forwards, becoming horizontal in the body, in which, anteriorly, it becomes superficial, communicating with the mental foramen, and by a series of fine channels with the bottom of the tooth sockets. The walls of the canal are compact at each end, cancellous intermediately.

The front and inner edge of the hole is a prominent, thin scale of bone, the **lingula mandibularis**, to which the spheno-mandibular ligament is attached. The lingula is notched below and behind, and from the notch a groove extends downwards for the mylo-hyoid vessels and nerve.

In front of the lingula is the continuation of the *linea obliqua interna*, which becomes less prominent as it ascends to the inner side of the coronoid process. Between this line and the anterior edge of the ramus are two surfaces, one rough and triangular behind the last molar tooth, covered with the hindmost tract of gum. Outside this is a narrow concave strip looking forwards and inwards, along which a portion of the tendon of the *temporal* is attached, covered by the mucous membrane of the hinder part of the vestibulum oris (§ 451).

The ramus ends above in two processes, the articular **condyle** behind, the **coronoid process** for the attachment of the temporal tendon, in front. Between these is a sharp-edged concave **sigmoid notch** transmitting the masseteric nerve and artery.

The **condyle** is thick, oblong, irregularly convex above, with its long

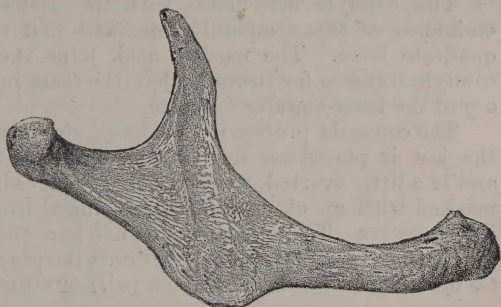


Fig. 344.—Mandible of old woman of ninety-seven, showing the mental foramen on the upper surface of the body of the bone, owing to the complete abolition of the alveolar arch.

axis directed so much backwards and inwards that if prolonged it will meet the axis of its fellow, 2.3 cm. behind the transverse intercondyloid line. It averages 16 mm. long and 9 mm. broad.

Outside the cartilage-clad upper surface is the **external condylar tubercle** for the attachment of the external lateral ligament; internally is an inner tubercle, articular above, rough and excavated below, where it overhangs the inner end of the pit on the neck of the bone for the insertion of the *external pterygoid* muscle. The investment of cartilage passes farther down on the back than on the front surface and ends in a well-defined line on all sides.

The condyle articulates with the glenoid cavity and with the articular eminence of the temporal bone, and just touches the tympanic or modified quadrate bone. The narrow neck joins the condyle to the ramus, but the condyle leans so far inwards that the least inter-condyloid distance is generally 0.9 of the inter-angular distance.

The coronoid process is a flattened sharp spur for muscular insertion. When the jaw is placed on the table it rises slightly above the level of the condyle, and is a little everted, with its point recurved. It is flat on its outer surface, and marked with an obscure ridge, continued from the internal oblique line, on its inner surface. To its front and inner part the *temporal* muscle is inserted, while to the inner edge of the ramus below it the *pterygo-mandibular* fascia and *buccinator* muscle are attached. Fifteen pairs of muscles are attached to the mandible.

In structure the mandible is dense, resisting decay longer than any other bone, and in operations it is hard to cut with a bone forceps. Compared with other bones its surface is poorly nourished, except by the inferior dental artery, and hence as it is exposed to injury and sometimes actually uncovered in its alveolar portion, it often necroses, especially if this artery be affected.

The tooth-sockets are twenty-two pits with ellipsoidal mouths, separated from each other by **juga** or rough bony ridges whose sides are perforated by closely-set minute holes. Each socket narrows to its fundus, which is rounded and pierced by a larger pair of holes for the vessels and nerve of the tooth.

The pair of sockets on each side of the symphysis are the smallest, and contain the fangs of the incisor teeth. The next on each side is the widest and deepest, and receives the canine; then follow two smaller, rounder pits for the bicuspids; then six hindmost, transversely elongated, bilobed hollows for the fangs of the three molar teeth, two for each. The bone is weakest and most commonly broken opposite the premolar sockets.

The alveolar arch is narrowest in front but widens posteriorly to its hinder fifth. In front the mouths of the sockets look upwards and forwards, behind they look upwards and inwards. Along the arch the bone is rough for the attachment of the gums. Close to the outer edge of the sockets of the last two molars is a faint rough line for the origin of the lowest part of the *buccinator* muscle.

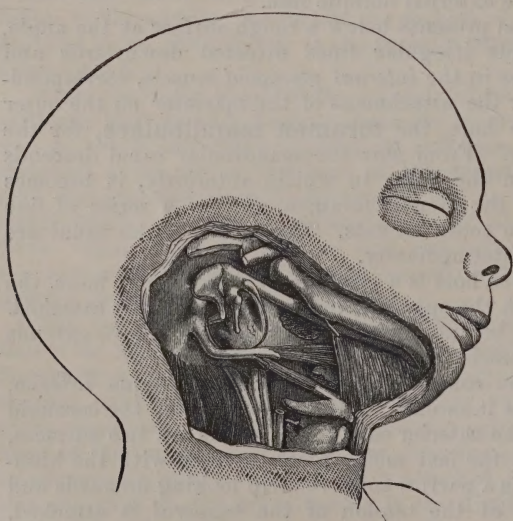


Fig. 345.—Head of sixth month fetus, showing Meckel's cartilage and auditory ossicles.

Development.—The mandible is subject to many age-changes. One centre of ossification begins in the embryonic tissue around Meckel's cartilage (fig. 345), on the thirty-eighth day. A supplemental patch of cartilage appears in this tissue at the angle, and a second at the condyle. Centres of ossification, condylar and angular, arise in each of these patches, and a third in the median end of Meckel's cartilage; a fifth, or splenic centre, arises in the

lingula. These all very rapidly unite, so that by the fourteenth week but one bony mass is present on each side.

At birth the jaw consists of a hollow arch, mainly alveolar, the basal part (that below the oblique lines) being only a thin shell, and the angle is one of 175° . When the first dentition is perfect, about four years, the angle has become 140° . With the second dentition the body grows and the angle becomes now about 118 , and the body is half basal part, half alveolar.

With old age and the loss of teeth the alveolar part atrophies, the mental foramen, which was low down in the child, now appears at the top of the body, which consists only of the basal part, the chin is thrown forwards, and the angle increases to 140 . The female jaw has a greater angle, a less prominent chin, and a weaker, sharper coronoid process than the male.

133. THE HYOID, a small, median, U-shaped bone beneath the chin at the base of the tongue, consists of a central body or **basihyal** and two pairs of lateral **cornua** (fig. 346).

The **basihyal** is placed transversely, with a posterior concave surface directed towards the top of the air passage, and a convex surface directed

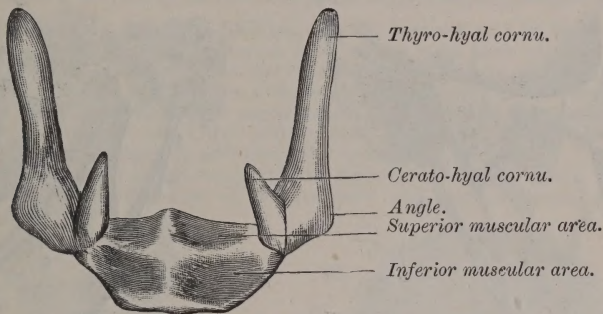


Fig. 346.—Hyoid bone.

forwards and upwards, marked by a vertical median line and a transverse horizontal ridge.

The greater cornua or **thyro-hyals** are flattened above, continued backwards from the body on each side, and present a projecting **thyro-hyoid angle** and a posterior rounded extremity, which is tied to the thyroid cartilage by a round ligament. The lesser cornua or **cerato-hyals** are short conical processes, which project upwards and backwards from the union of the body and greater cornua, and are attached by their tips to the stylo-hyoid ligaments.

To the upper surface of the basihyal are attached the hinder fibres of *genio-hyo-glossus*, *genio-hyoid*, and *mylo-hyoid*; the *sterno-* and *omo-hyoid* are attached to the transverse ridge, and the *thyro-hyoid* below the ridge. The thyro-hyoid membrane is attached to the posterior surface, not to the lower border, while to the upper and back edge is attached a mass of connective tissue, tying the epiglottis to the bone.

To the flat upper surface of the thyro-hyal cornu is attached the *hyo-glossus*; to its lower surface as far as the angle, the *thyro-hyoid*; to its hinder end the *hyo-pharyngeus*.

To the cerato-hyal is attached the *stylo-hyoid* muscle, and to it and the great cornu at its base is attached the sheath of the tendon of the *digastric*.

The basihyal begins to ossify from a pair of small centres in the eighth month. After their coalescence, a centre appears in the great cornu at the beginning of the ninth month, and in the lesser cornu in the second year. The great cornu is joined to the body by synchondrosis until about thirty, when it becomes synostosed to the body; the lesser cornu is a rudimentary process, and seldom consolidates.

The hyoid has six named processes, six centres of ossification, and gives attachment to ten pairs of muscles.

134. THE TEMPORO-MANDIBULAR JOINT forms a double condylar-throsis, wherein the articular surfaces are dissimilar, but fitted together by an intervening interarticular cartilage whose margins are inseparably attached to the capsule. The joint can best be seen when the jaw is divided in front of

the ramus, and the parotid gland and the muscles of mastication removed; the capsule and its accessory ligaments are then exposed; the latter are three:—

1. **Stylo-mandibular ligament** (fig. 348, 9), a specialised band of cervical fascia passing from the styloid process (*ib.*, 3) near its apex to the hinder edge of the ramus at and above the angle of the jaw, the motions of which it regulates.

2. **Pterygo-mandibular** ligament, a band with rather indeterminate borders, passes from the root of the hamular process to the hinder fifth of the linea obliqua interna, giving attachment to the *superior constrictor* behind, to the buccinator in front.

3. **Spheno-mandibular** (*ib.*, 8), the most definite of the three, is attached above to the lower surface of the spine of the sphenoid and below to the lingula

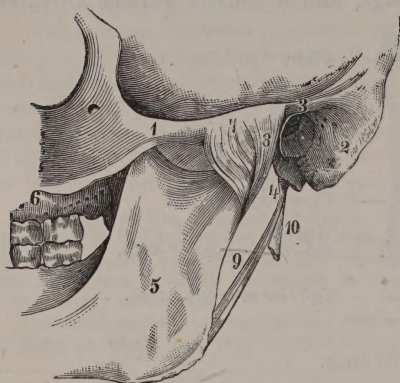


Fig. 347.—Outer surface of left temporo-mandibular joint.

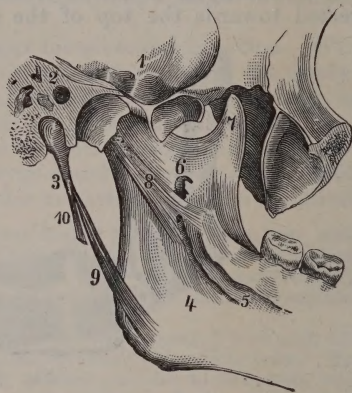


Fig. 348.—Inner surface of left temporo-mandibular joint.

mandibularis. Between its surface and the neck of the lower jaw pass the internal maxillary artery, the inferior dental nerve, and a lobule of the parotid. These three are all specialised parts of a continuous layer of cervical fascia.

The **capsular ligament** (fig. 347, 7) is attached around the margin of the cartilage-covered area of the glenoid cavity and articular eminence, extending inwards as far as the edge of the sphenoidal spine and backwards to the Glaserian fissure. Below, it is attached around the margin of the condyle of the lower jaw. From the glenoid tubercle a strengthened, but not separate, band, sometimes called the *external lateral ligament*, descends a little backwards along the hinder edge of the masseter to the neck of the jaw (*ib.*, 8).

The **interarticular cartilage** (fig. 349, 8) is an irregular plate whose upper surface corresponds to the articular area of the squamosal, and is therefore concave in front, convex behind. Its lower surface is closely fitted to the condyle of the jaw. It is clothed with synovial membrane on each surface, the two articular cavities being generally separate, the upper much the larger. In the closed mouth the condyle occupies the glenoid cavity, the cartilage lying above and in front of it, with the upper and back part of the capsule relaxed. In opening the mouth the condyle slides forwards on the articular tubercle, carrying the cartilage with it, making tense the supra-cartilaginous part of the capsular ligament behind. This can be ascertained during life by moving the jaw while the finger is placed between the condyle and the ear.

The motions of the jaw are—(1) Rotation around a transverse axis traversing the bone below and behind the lingula. It is at this spot of least movement that the inferior dental

nerve enters the jaw. This rotation produces opening and closure of the mouth, and the chief seat of movement is the temporo-cartilaginous joint, the cartilage with the condyle moving forwards on the temporal. In the small movement of the jaw during ordinary speech the motion is usually confined to the lower joint, as is the motion of opening the dead jaw forcibly. (2) The jaw can be protruded without opening the mouth, but with a depression of the angles; in this the motion is confined to the upper joint, and the anterior fibres of the masseters are tense. (3) By unilateral protrusion the jaw can be rotated around a nearly vertical axis, the moving condyle slipping out of the glenoid cavity on the articular tubercle in front.

135. WORMIAN BONES.—Detached ossicles, known as Wormian bones, are often to be seen in the lambdoidal suture, and more rarely in other sutures. These result from the presence of supernumerary ossific centres, and are not to be confounded with the separate bones, caused by want of union of the normal centres. The persistence of the separation of the upper part of the supraoccipital and of the lower part of the malar are examples of the latter condition, and are not Wormian bones. Ossicles are frequently met with along the orbital margin, reminding us of the multiple suborbital bones in lower vertebrates. The different forms of Wormian bones will be treated of along with other variations. They are a testimony to the low morphological value of centres of ossification in membrane bones.

136. DEVELOPMENT OF THE SKULL.—In the foremost part of the embryo, owing to the enormous development of the neural canal whose walls have expanded into a vast brain case, the several segments of which the cranium was originally composed have undergone fusion. This coalescence took place so far back in the history of vertebrates that little trace survives of any original metameric segmentation, and although from analogy we assume that the primitive vertebrate skull was polyarthrous, yet the so-called division of the head into vertebral segments is generally untrustworthy and often fanciful.

We have already noticed the formation of the three brain vesicles (§ 11). In the tissue around the notochord, on the floor of the posterior and middle vesicle, chondrification

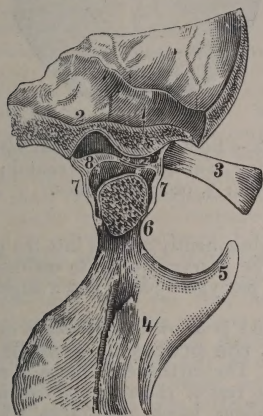


Fig. 349.—Sagittal section through the temporo-mandibular joint, showing the interarticular cartilage—1, articular eminence; 2, glenoid cavity; 3, zygoma; 4, lingula; 5, coronoid process; 6, neck; 7, capsule.

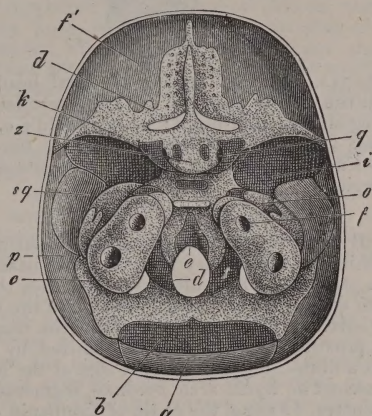


Fig. 350.—Inner surface of base of skull of fourth month fetus, showing the cartilage and membrane elements—*a*, membranous supraoccipital region; *b*, cartilaginous supraoccipital; *d*, cartilaginous exoccipital; *e*, basioccipital; *p*, parietal; *sq*, squamous plate of temporal.

sets in at the end of the second week, and an irregular **basilar plate** is formed, which makes a floor for these vesicles, but involves very little of their lateral walls and only a narrow hindmost strip of their roof. As the middle portion of this plate, in its rapid growth, encroaches on the notochord, two dilatations of the latter appear, possibly comparable with the intervertebral enlargements in the spinal column. This cartilage of the basilar plate is on each side distinguishable into two parts, a **parachordal** lying on each side of the notochord and extending to the middle of the mid-vesicle, and a **trabecula** or prechordal portion beginning behind as a divergent process, which approaches and coalesces with its fellow anteriorly.

In the floor of this cartilaginous brain-case on each side perforations for the cranial nerves

develope early, indicating lines of segmentation, but even these are of uncertain value from our want of accurate knowledge of the segmental relations of the cranial nerves.

The membranous wall of the head begins in the seventh week to show traces of ingrowing partitions, dividing the included cavity into compartments (fig. 351).

Along the side of the skull, as we have seen (§ 15), a series of surface-invaginations dip into the wall of the developing skull to form the sense capsules. The hindmost of these are the auditory vesicles, whose outer capsule chondrifies and forms an integral part of the side wall of the cranium. Farther forward are the eye capsules, which indent the skull wall into pits called orbits; still farther forward are the nasal cavities, separated from each other by the anterior extension of the fused trabeculae. The skull, as thus formed, consists of a cartilaginous base, with the sense-capsules on either side and membranous sides and roof, ending in front in the frontal and maxillary processes already described (p. 16).

137. VISCERAL SKELETON.—From the under surface of the basilar plate separate cartilaginous bars extend into the three upper visceral folds (§ 20). That in the first joins its fellow medio-ventrally behind the oral invagination forming the mandibular arch, that in the second is the hyoid arch, that in the third is imperfect and forms the thyro-hyal cornu.

From the base of the first arch a process extends forwards and inwards towards the middle line above the oral invagination, the **pterygo-quadrate cartilage**, in front of which

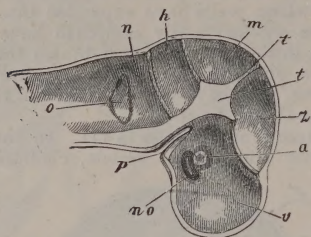


Fig. 351.—Vertical section of foetal head in the eighth week—*d*, eye; *h*, cerebellar region; *m*, mid-brain; *n*, neck-fold; *o*, ear vesicle; *p*, pituitary fossa; *t*, tentorium; *z*, thalamic region; *v*, cerebral region.

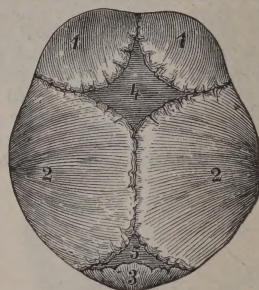


Fig. 352.—Roof of fetal skull at birth, showing fontanelles—1, frontal; 2, parietal; 3, occipital bones.

is a small separate area of cartilage, the palatine, which subsequently ossifies into the palatine bone behind the maxillary process on the nasal floor. The pterygo-quadrate ossifies in two parts, a pterygoid which ultimately becomes the internal pterygoid plate, and a degenerated quadrate which becomes transformed into the tympanic.

The cartilage which stretches into the mandibular fold is known as Meckel's cartilage, and its proximal or articular end is united by a ligament, the **processus gracilis**, which becomes a fibro-cartilage, with the base of the hyoid arch. The cartilage of the basal segment of the second or hyoid arch becomes segmented from the rest of the arch and ossifies from three centres, forming the chain of tympanic ossicles, malleus, incus, and stapes, which can best be studied in connection with the cavity of the tympanum (§ 537). The rest of this arch forms the styloid process, stylohyal ligament, and basihyal. This system of arches constitutes the visceral skeleton.

138. OSSIFICATION commences early in the human skull, first appearing in the tissue of the mandibular arch around Meckel's cartilage in the fifth week. Some centres appear in the membrane of the roof and sides, others in the cartilage of the base; we have thus a historical subdivision of the bones of the skull into those which have had a preceding cartilage stage and those which have not. Eighty-three centres in all appear usually in the human skull, twenty-eight in the cartilage of the skull itself, twenty-nine in membrane, twenty-six in the arches. These, however, do not remain separate, but in the course of growth they coalesce in groups, making the twenty-nine cranial bones already referred to.

The elements which we have thus seen to make up the skull may be classified as follows:—

1. **Elements of the cranio-facial axis.**—(a.) *Ossifying in cartilage*, basioccipital, basisphenoid, presphenoid, mesethmoid.

(b.) *Remaining permanently cartilaginous.*—Cartilaginous septum nasi.

(c.) *Ossifying in the membrane underlying the cartilage.*—Vomer.

(d.) *Ossifying in the membrane over the cartilage.*—Dorsum ephippii.

2. **Elements of the lateral wall and roof of skull.**

(a.) *Ossifying in cartilage*.—Supraoccipital, exoccipital, the various components of the petrosal (auditory sense capsule), alisphenoid, orbitosphenoid.

(b.) *Ossifying in membrane*.—Interparietal, parietals, squamosals, frontals, post-frontals or pterion ossicles, prefrontals or fronto-lacrymal ossicles.

(c.) *Remaining cartilaginous*.—Petro-occipital cartilage, and the mass in the foramen lacerum anterius.

3. Elements of nasal capsules.

(a.) *Cartilaginous*.—Ethmo-turbinals, sphenoturbinals, inferior turbinals.

(b.) *Membranous splints*, nasals.

4. *Suborbital membranous splints*.—Lacrymal, part of maxilla, malar.

5. Skeleton of visceral arch system.

1. Of first arch—

Ossifying in cartilage.—Pterygoid, palatines, mento-meckelian part of mandible.

Ossifying in membrane.—Maxilla, malar, premaxillary, tympanic, most of the mandible.

2. Second arch—

(a.) *Ossifying in cartilage*.—The malleus, incus, stapes, styloid process, basi- and cerato-hyals.

139. FONTANELLES.—In the roof of the skull at birth are six unossified interosseous spaces called fontanelles. These are (1) the **anterior** (fig. 352, 4), occupying the bregma, a lozenge shaped space to which four sutures, sagittal, frontal, and the two halves of the coronal concur; (2) **posterior** (fig. 352, 5), smaller, triangular, with three concurrent sutures, the sagittal in front and the two halves of the lambdoidal on each side; (3) **antero-lateral** on each side, occupying a small space, the pterion, between the frontal, parietal, and sphenoid bones; (4) **postero-lateral** in the asterion between the squamosal, petrous, parietal, and occipital bones. In the filling of the last two pairs the development of Wormian bones is not uncommon.

140. THE HUMAN SKULL is characterised by (1) its enormous brain space; (2) its proportionally small jaw arch; (3) its being supported on the vertebral column, and therefore attached to the trunk by a comparatively weak musculature; (4) its being slower of consolidation than most other mammalian skulls, but its elements are fewer and more condensed; (5) owing to the diminished size of the nasal fosse and the increased width of the parietal lobes of the brain the orbits are thrown close together so as to be nearly parallel, with a diminished interorbital width. Some bones, such as the membrane bones roofing the skull, the alisphenoid, malar, and the petrous, have undergone increased development; others, such as the lacrymal, ethmoid, and palate, have become retrogressive; and other elements, such as the pterygoids, interparietals, and premaxillæ, have coalesced with others.

The skull varies in shape at different ages. In the skull at birth the upper part is disproportionately large when compared with the base; and while some bones, like the lacrymal and the ear ossicles, are large and perfect, others are very imperfectly formed. The face is proportionally small, the teeth undeveloped and unossified. The greatest cranial length is in the occipital and temporal regions.

Coincidentally with the first dentition the face enlarges and the jaws lengthen, the fontanelles close and the zygoma projects. The temporal region elongates at the expense of the occipital. The second dentition is attended with still more marked changes and the completion of ossification and the attainment of the adult shape and size. The skull grows little in capacity after thirteen, indeed its rate of growth from seven to thirteen is slow in comparison with that from birth to seven years. In the later years of growth the muscular crests develop and the air passages and air cells expand, and the frontal region elongates.

In old age the skull undergoes atrophy, the air cells enlarge as the inner table follows the shrinking brain, the jaws become edentulous, the upper retreats, and the chin becomes prominent.

The child's head is more perfectly balanced on the vertebral column than that of the adolescent after the second dentition, as the facial region then grows considerably in weight. In the old man, from the bowing of the vertebral axis the head is thrown backwards. At different ages these gravitation changes produce effects on the plane of the occipital condyles.

The male skull is larger, heavier, more ridged, than the female, with more prominent mastoid processes, occipital protuberance, zygomatic and superciliary ridges, and a larger capacity (11 : 10), especially in the frontal and occipital regions. The female skull preserves a look of immaturity, and such characters of immaturity as the preponderance of temporal length over frontal, the prominence of the parietal tubera and the concomitant narrowness of base.

The following measurements are of importance in determining the racial and other characters of skulls:—

1. **Maximum length** from glabella (p. 218) to the most prominent point of the occiput : this averages in the male, 19·6 cm. ; in the female, 18·3 cm.

2. **Length of brain case** from the ophryon (or middle of the line drawn across the fore-

head between the most closely approximated points of the temporal crest) to the most prominent occipital point. This differs from the other in being above the frontal sinus, and consequently gives only the length of the brain-case uncomplicated by the variable factor of the size of the sinuses.

3. Maximum breadth from the most prominent point of one parietal to the other.
4. Height from basion or anterior lip of foramen magnum to the bregma.
5. Basinasal length from basion to nasion (p. 193).
6. Basialveolar length from the basion to the mid-point of the maxillary alveoli.
7. Greatest horizontal circumference taken round the glabella and the most prominent part of the occiput; this averages 52 cm.

The comparison of different skulls is most effectively made by reducing absolute to relative measurement; thus we can describe the breadth of a skull in terms of its length, by the formula $\frac{\text{breadth} \times 100}{\text{length}}$. The result is called the *cephalic index*. $\frac{\text{height} \times 100}{\text{length}}$ gives the

altitudinal index. Where the cephalic index is below 75 the skull is called *dolichocephalic*, when above 80 it is called *brachycephalic*, when between these limits it is called *mesocephalic*. The degree of prominence of the jaws is measured by an alveolar index $\frac{\text{basialveolar} \times 100}{\text{basinasal length}}$. Variations in form of the nose are determined by a nasal index

$\frac{\text{greatest nasal width} \times 100}{\text{nasal length}}$ = the length being the distance between the nasion and the horizontal

line drawn along the lowest border of the pyriform aperture. Variations in orbital shape are shown by an orbital index $\frac{\text{orbital height} \times 100}{\text{orbital width}}$. When the alveolar index is less than 98,

the skull is orthognathic, when more than 103, prognathic, when intermediate it is mesognathic. If the nasal index exceed 53 the nose is platyrhine, if it fall short of 48 it is leptorhine, if between these numbers it is mesorhine. Similarly an orbital index above 89 is called megaseme, one under 84 is microseme, one between is mesoseme.

The cranial capacity is best determined by carefully filling the skull through the foramen magnum with No. 8 shot, using a funnel and a tapering rammer to ensure filling of the whole cavity; leakage through the foramina being prevented by plugging them with cotton wool, then the shot is emptied into a graduated measure. A skull whose capacity exceeds 1,450 c.cm. is megacephalic, one under 1,350 c.cm. is microcephalic, and one intermediate is mesocephalic. The weight of the brain in grammes may be approximately obtained by multiplying the capacity in c.cms. by 0.87. The average capacity of the European male skull is 1,570 c.cm., that of the European female, 1,378 c.cm. The maximum and minimum frontal diameters, the occipital and bi-auricular diameters, the bizygomatic and inter-orbital diameters, and the facial height are also measurements of importance.

The average of the threefold circumference is usually correlated, though not very definitely, with capacity—a skull of a capacity of 1,560 c.cm. has a horizontal circumference of about 524 mm., a vertical circumference of 504, and a transverse of 452, making an average of 493; while one of a capacity of 1,179 has the same three measurements, 491, 483, 400, average 458.

The study of other measurements and of those of different races will be discussed subsequently in connection with the variations in structure.

THE BACK.

141. The body, having been turned with its ventral side downwards, should be raised by placing a block under the thorax, and another under the loins; the head should then be bent downwards so as to make tense the structures on the back of the neck, and the arm is to be drawn outwards from the side.

Surface Markings.—The spinous processes of the vertebræ are palpable through the skin in the middle line, projecting most prominently at the nape; but from this region downwards to the sacrum they are sunk into a furrow, on each side of which the deep longitudinal muscles form a rounded projection. The spine of the scapula can be felt on the level of the fourth dorsal spine, ascending outwards to the point of the shoulder, and the inferior angle of the scapula is on the level of the seventh dorsal spine. The vertebral spines become more conspicuous on flexion of the column. §

The area of the back is isolated laterally by a vertical line drawn from the hinder fold of the axilla to the iliac crest, and is divided into nine regions, one median, the **interseapular**, and four on each side; **superior scapular** above the spine of the scapula, **inferior scapular** below the spine, and above the plane of the inferior angle; **infrascapular** between the last and the level of the eleventh rib; **posterior lumbar** between the infrascapular and the iliac crest.

Integument.—The epidermis on the back is thin, averaging 0.15 mm. in thickness, and beset with very fine short hairs, directed downwards and inwards, averaging 16 to the square cm. The corium has a thin *stratum papillare*, beset with few irregular papillæ, and so low in sensibility that the points of the æsthesiometer must be separated 4.5 cm. on the loins and 6 cm. on the shoulders before a double impression is produced. The sweat glands are sparse, 73 to the square cm. above, 95 below, those of the loins being of large size. The sebaceous glands are large in the superior scapular region and liable to acnous inflammation.

The *stratum reticulare* is unusually thick and merges into a dense superficial fascia of great toughness and low vascularity, which becomes hypostatically congested and discoloured when the body lies long on its back, and as it is occasionally the seat of carbuncle is sometimes called the “carbuncular tissue.” It is less adipose, more loosely meshed, and often gelatinous in appearance in the lumbar region, and is attached to the supraspinous ligaments along its entire extent.

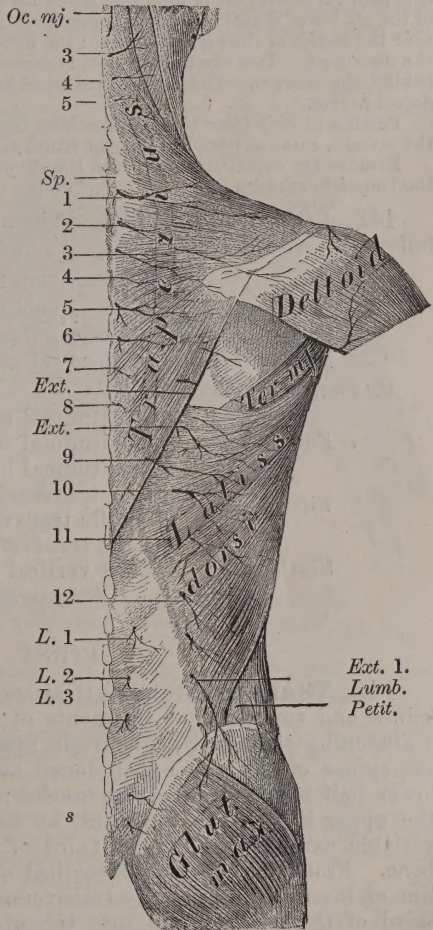


Fig. 353.—Muscles of the first layer of the back, with the superficial nerves.

Dissection.—Make a longitudinal median incision from occiput to sacrum, and two transverse incisions, one from the acromion and the other from the crest of the ilium inwards to the middle line. Reflect the skin outwards in two flaps, avoiding the cutaneous nerves which in the upper half of the region become superficial at the sides of the spinous processes. Each of these nerves should be fully exposed by the removal of the surrounding tissue. These are the internal branches of the posterior spinal nerves (p. 58, fig. 104), the first and largest of which, derived from the second cervical nerve, emerges on a level external to the rest, but should not be followed as yet. The second of these nerves, from the third cervical nerve, ascends vertically from the level of the third cervical spine. The next pair are much smaller, and ascend obliquely outwards from the fourth and fifth cervical nerves. Still lower, at the first dorsal spine, is the fifth of these cutaneous branches arising from the first dorsal nerve, below which are five branches from the second, third, fourth, fifth, and sixth dorsal nerves, whereof the first pair, from the second and third, are the largest and can be traced outwards across the scapula. Internal cutaneous branches are seldom demonstrable from the three lowest cervical nerves.

Below the angle of the scapula, and internal to a vertical line prolonged downwards from this point, a second set of nine cutaneous nerves appear, derived from the external branches of the six lower dorsal and three upper lumbar posterior spinal nerves. The former emerge near the angles of the respective ribs; the latter descend, ramifying over the hinder third of the iliac crest. Two small cutaneous branches of the posterior sacral nerves pierce the fascia behind the sacrum. The dorsal area of skin, as above circumscribed, is supplied by these dorsal nerves.

Patches of very loose tissue, sometimes becoming bursæ, are met with over the spine of the seventh cervical vertebra (*bursa nuchalis*), and over the sacrum (*bursa sacralis*).

Remove the superficial fascia and the subjacent areolar tissue which forms the sheath of the trapezius muscles.

142. DORSAL MUSCLES.—The muscles of the back are divisible into the following series:—

A. Dorsal extensions derived from the ventral muscle of the somatopleure.

First layer,	spino-appendicular = <i>Trapezius</i> , <i>Latissimus dorsi</i> .
Second layer,	spino-scapular = <i>Rhomboideus</i> .
Third layer,	spino-costal = <i>Serrati</i> .

B. Dorsal muscles—

Fourth layer,	{	longitudinal external = <i>Iliocostalis</i> , <i>Splenius</i> .
		longitudinal medial = <i>Longissimus</i> .
		longitudinal internal = <i>Spinalis</i> .
Fifth layer,	{	long transverso-spinals = <i>Semispinalis</i> .
		middle transverso-spinals = <i>Multifidus</i> .
Sixth layer,	{	short transverso-spinals = <i>Rotatores</i> .
		short vertical muscles = <i>Interspinales</i> , <i>Inters transversales</i> .

FIRST LAYER.

143. TRAPEZIUS (fig. 353) arises (*a*) by short tendinous fibres from the spines and supraspinous ligaments of the ten lower dorsal vertebræ; (*b*) by a glistening semi-oval aponeurosis, *speculum rhomboideum* (*ib.*, *Sp.*), from the spines of the two upper dorsal and last cervical vertebræ, and from the lower half of the ligamentum nuchæ; and (*c*) by short tendinous fibres from the upper half of that ligament, as well as by an areolar expansion from a variable extent of the inner third of the upper nuchal line of the occipital bone. From this continuous vertical origin the fibres converge to an angular line of insertion, in a nearly transverse plane, into the upper edge of the outer third of the clavicle, and into the upper edge and adjoining surface of the acromion and spine of the scapula as far as the tubercle of the spine (p. 135).

The clavicular part which arises above the nuchal aponeurosis is a skew quadrilateral, whose planes of origin and insertion intersect at an angle of 80°. The supraspinous part arising from the aponeurosis is a rhomboidal muscle ($\phi = 20^\circ$), and the dorsal part is triangular with the apex at the tendon of insertion which glides over the basal triangle of the

spine of the scapula, and is inserted into the tuberculum spinæ. Over the basal triangle is a layer of loose connective tissue, rarely a bursa.

The *trapezius* covers the deeper muscles of the back, the *supraspinatus*, part of the *infraspinatus* and *latissimus dorsi*. It is superficial throughout. The lowest fibres ascend at an angle of 30° . Its fascicles vary from 10 to 15 cm. in length.

Morphologically the *trapezius* is one of the visceral striped muscles developed from the tissue at the base of the somatopleure and displaced outward to act on the shoulder-girdle (see § 409).

At its cervical border directly above the superior angle of the scapula, it receives the spinal accessory nerve which unites with branches of the third and fourth cervical nerves, and passes backwards and downwards beneath the muscle to supply it. Its nutrient arteries are the superficialis colli and the minute dorsal branches of the intercostals. The whole muscle can retract the scapula, and rotate it on a sagittal axis, raising the shoulder (§ 487).

Dissection.—Divide the *trapezius* by an incision from the middle of its cervical edge above the spinal accessory nerve to the middle of its lower edge. Reflect it, taking care to preserve and clean the branches of the superficialis colli artery, and the nerves on its deep surface.

144. LATISSIMUS DORSI (fig. 353), well named, arises (*a*) from the lower six dorsal spines and supraspinous ligaments, (*b*) from the outer and back part of the lumbar fascia, (*c*) from one-fifth of the outer lip of the iliac crest in front of the posterior gluteal line, and (*d*) from the lowest three ribs. The fibres ascend converging, and, being applied first to the hinder, then to the anterior surface of the *teres major*, form with it the posterior fold of the axilla. It ends in a flat tendon about 3.5 cm. broad, which is inserted into the floor of the bicipital groove in front and above the *teres major* from which it is separated by a bursa (fig. 354, *d*); although the tendons are often marginally connected. Its fibres twist on themselves, the lowest becoming uppermost and *vice versa*, so that the front of the tendon is continuous with the back surface of the muscle.

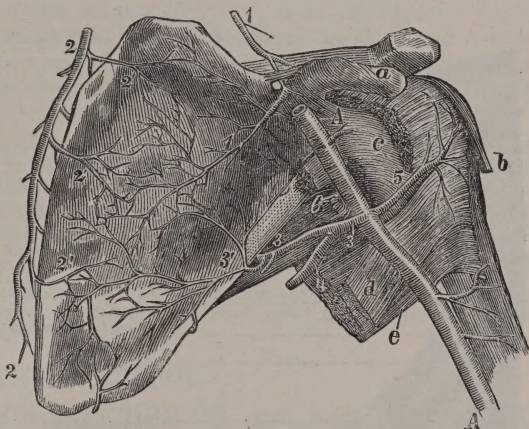


Fig. 354.—Insertion of latissimus dorsi.
(For other references, see § 425).

The extreme fibres of this triangle form with each other an angle of 65° (50° in the sixth month foetus). The fascicles are not very different in length at its different parts, but the upper which cross (and rarely receive a slip from) the angle of the scapula, are slightly the shortest. When the front edge of this muscle does not overlap the *external oblique* below, a small triangle (Petit's) intervenes, bounded below by the crest of the ilium, and floored by the *internal oblique* muscle of the abdomen. This space almost always exists in adult females, in about 32 per cent. of adult males: it first appears about twelve years of age, before which time the *latissimus* overlaps the *external oblique* (fig. 353).

This muscle is superficial, except at the upper part of its origin where the *trapezius* covers it, and at its insertion in the axilla where the brachial vessels and nerves cross it. Behind the scapula and between this muscle and the *trapezius*, is a small post-scapular triangle, wherein the *rhomboid* muscle appears, and when the scapula is drawn forwards a small area of the sixth and seventh ribs and the sixth interspace become subcutaneous. The *latissimus* lies on the *rhomboid*, *teres major*, *inferior serratus*, and *external intercostal* muscles and on the ribs.

Crossing the tendon at its insertion are vertical fibres of the internal intermuscular

septum of the arm which are continued upwards to the shoulder capsule (fig. 387). In early fetal life the uppermost fibres are attached to the areolar sheath of the vessels, and some of the lowermost to the long head of the *triceps*. These connections usually atrophy, but may persist, forming in the one case a muscular band, one form of the *dorsi-axillaris*, crossing the axillary vessels (fig. 371, 11), in the other a rudimental *dorsi-epitrochlearis* muscle.

Its nerve, the long subscapular, derived from the fifth cervical, enters it with a branch of the subscapular artery on its axillary side on the level of the fourth rib. This muscle adducts, retracts, and rotates inwards the arm, acting along a line joining the fourth lumbar spine to the mid-point of its insertion.

Dissection.—Divide the *latissimus dorsi* by an oblique incision carried downwards and forwards from the inferior angle of the scapula to the middle of the anterior inferior edge of the muscle. The parts covered by these two muscles of the first sheet are now exposed. The *teres major*, to be subsequently examined, is a deeper segmentation of this muscle (p. 284).

SECOND LAYER.

145. RHOMBOIDEUS underlies the dorsal portion of *trapezius*, appearing for a small extent in the post-scapular triangle, especially when the arm is raised. It arises from the supraspinous ligaments and spines of the seventh

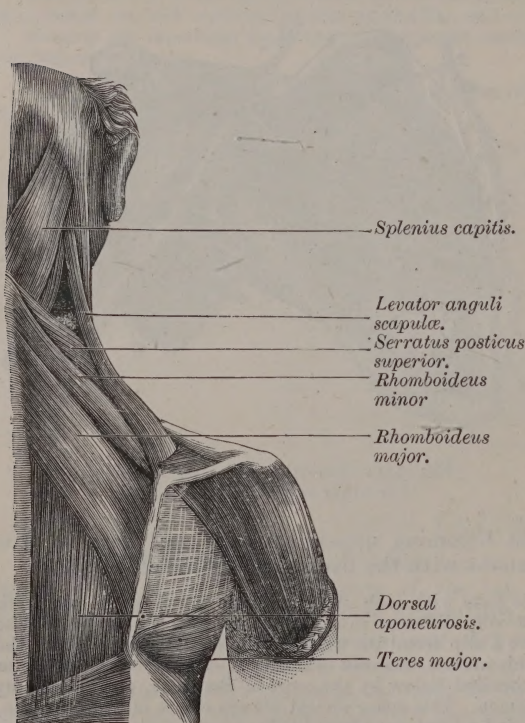


Fig. 355.—Muscles of the second layer attached to the scapula.

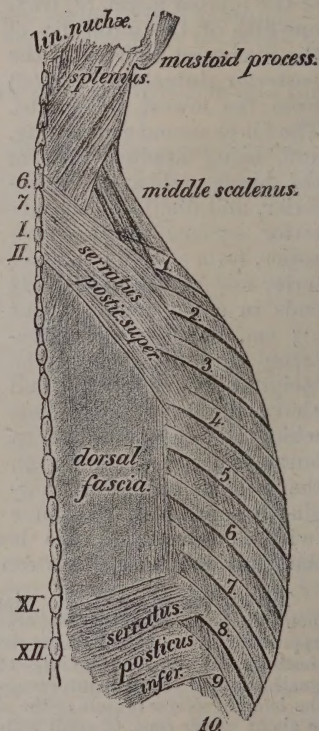


Fig. 356.—Muscles of the third layer.

cervical and four upper dorsal vertebrae; and is inserted (a) into the hinder margin of the scapula opposite and a little below the spine (b) into the lower fourth of this margin, and (c) into a flat tendinous sling from the upper to the lower bony attachment, more or less united to the infrapinnous fascia and hinder border of the bone. The slip from the two upper vertebrae is generally

separable and named **rhomboideus minor**, the rest being called **rhomboideus major**.

Its nerve, from the fifth cervical, emerges at the back of the *middle scalene* muscle, passes under the *levator anguli scapulae* and enters the upper border and anterior surface of the muscle at its outer third.

The fibres descend at an angle of 35° and the muscle acts along a resultant, whose direction is from the lowest point of quadrisection of the scapular border to the third dorsal spine.

The *rhomboid* is a deep delamination of the *trapezius*, and primarily arose from the dorsal aponeurosis whereof its tendon is a derivative. In the fifth month foetus this fascial origin extends downwards as far as the level of the sixth dorsal. The *rhomboid* overlies the *serratus posticus superior*, posterior scapular artery, deeper spinal muscles and rib-angles.

Dissection.—Divide the *rhomboid* 5 cm. from its insertion and reflect it, noting the course of its nerve, and cleaning the posterior scapular artery which is now exposed.

146. LEVATOR ANGULI SCAPULÆ (fig. 358, 20), although not belonging to the system of dorsal muscles, is now most conveniently dissected. It arises from the four upper cervical transverse processes by slips, of which the first and second are the largest, and are tendinous at their origin. These, coalescing, form a prismatic muscle which descends a little backwards to be inserted into the hinder margin of the scapula (fig. 355), from the superior angle to the root of the spine. It is innervated by branches from the third and fourth cervical nerves, and has the cervical plexus and *scaleni* muscles on its front surface, but as these cannot be seen in the present dissection, it should not yet be divided.

The superficial cervical artery passes over it to sink under the edge of the *trapezius*, and is distributed to both muscles and to the neighbouring lymphatic glands. The posterior scapular artery (fig. 374) lies under the *levator* and turns downward along the hinder margin of the scapula towards its inferior angle, supplying branches to all the surrounding structures. (For these arteries, see §§ 162 and 425.)

Dissection.—Draw the scapula from the side and clean off the tough connective tissue, rich in elastic fibres, poor in vessels, which connects the deep surface of the *serratus magnus* muscle to the side wall of the thorax. It can be seen in this dissection that the *levator anguli* and *serratus magnus* are dismemberments of the same great lateral lamella, whose relations can be better studied from the front.

THIRD LAYER.

147. SERRATUS POSTICUS SUPERIOR (fig. 356) arises by a tendon, which is a specialised part of the dorsal aponeurosis, from the ligamentum nuchæ and from the seventh cervical and two upper dorsal spines. The upper part of the tendon appears above the *rhomboideus* which covers most of the fleshy part. The fibres are inserted by four slips into the posterior and outer surfaces of the second, third, fourth, and fifth ribs external to their angles. Its nerves, which are fine filaments from the second and third intercostals, pierce the muscle on its deep surface together with small branches from the intercostal arteries. It raises the ribs.

Its fascicles average 3 cm. in length and descend at an angle of 50° .

Serratus posticus inferior, larger but less defined than the superior, beneath and connected to the *latissimus dorsi*, arises from the lumbar fascia opposite the two lower dorsal and two upper lumbar spines, and ascending outwards at an angle of 30° is inserted fleshily into the four or five lower ribs which it depresses, so enlarging the thorax downwards, and fixing the lower ribs for the action of the diaphragm. Its nerves are from the tenth and eleventh intercostals.

The *serrati postici* are the remnants of a supracostal muscle, the deepest stratum of the displaced ventral lamella. The intervening part between the upper and lower has degenerated into an areolar expansion attached to the septum between the dorsal and ventral muscles.

148. LUMBAR FASCIA.—On removing these muscles the **lumbar fascia**, with its weaker dorsal extension, is brought into view. This structure is the fascial investment of the mass of dorsal muscles overflowed by those displaced portions of the ventral system of muscles just described, which the scapula has carried backwards with it. Above, the dorsal fascia becomes lost in the sheaths of the several muscles, parts of it being specialised as the tendons of the *rhomboideus* and *serrati postici*, beneath which it is continued upwards into

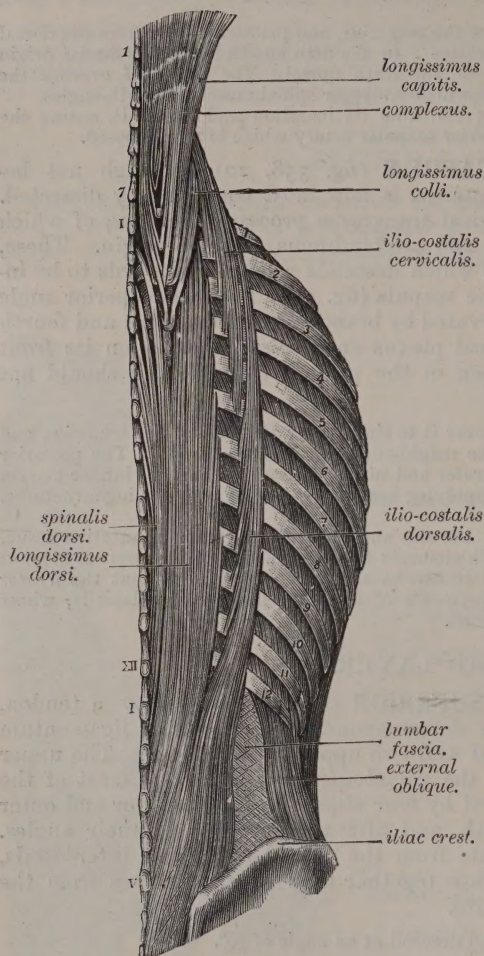


Fig. 357.—Erector spinæ and its derivatives.

the neck. Below the *serratus inferior* it becomes the thick and strong lumbar fascia, which consists of two layers of transverse white fibres with an intermediate vertical layer, and is attached internally to the vertebral spines, externally to the last two ribs, and below these, to the margin of the lateral intermuscular septum as far as the hinder third of the iliac crest, to which, and to the sacrum below, it is also attached. This strong fascia forms a natural girding of the loins, and gives attachment by part of its deep surface to the muscles it covers, from which it is separated above by lax areolar tissue.

Dissection.—Divide this fascia vertically, and clean the subjacent muscles, leaving intact the emerging row of nerves and vessels.

FOURTH LAYER.

149. ERECTOR SPINÆ is the great muscular column in the loins which arises by very short tendinous fibres from the inner part of the tuberosity of the ilium and from the hinder fifth of the iliac crest, from the sacro-iliac ligaments, and from the backs of the arches and costal processes of the lumbar vertebræ, as well as by a strong superficial tendon from the spinous processes of the sacral, lumbar, and lower two dorsal vertebræ. At the level of

(A) **Ilio-costalis** consists (1) of the iliac and lumbo-costal fascicles of the *erector*, which ascend on the backs of the ribs inclining a little outwards, and giving off along its outer border a series of nine tendons, which are inserted

into the angles of the nine lower ribs; (2) by drawing this portion of the muscle outwards from the longissimus a second part is exposed, consisting of shorter fascicles, which arise by flat tendons from the upper edges of the lower ten ribs internal to their angles. These accessory fascicles ascend and are inserted—the three lowest into the three highest tendons of the first part of the muscle, the three succeeding into the angles of the three upper ribs, continuing the series, and the four uppermost into the transverse processes of the fourth, fifth, and six cervical vertebræ. The first part of this muscle is sometimes called *ilio-costalis lumbalis* (*sacro-lumbalis*), the lower six slips of the second part are sometimes artificially separated as *ilio-costalis dorsalis* (*museuli accessori*), and the upper four lips are called *ilio-costalis cervicalis* (*cervicalis ascendens*).

The upper cervical portion of this series of muscles has undergone much specialisation and displacement, and through its investing fascia has gained an extensive origin from spinous processes, appearing superficially in the neck under the *serratus superior*, as the muscle next to be described.

(B) **Splenius.**—Thin and pointed below, arises tendinously from the last cervical and six upper dorsal spines, and from the lower two-thirds of the ligamentum nuchæ. The fascicles ascend outwards as a continuous sheet which divides above into two portions, the lower of which (*splenius colli*) is inserted into the two uppermost cervical transverse processes, and the upper (*splenius capitis*) is inserted into the lower and back part of the mastoid process and the contiguous splenial area below the upper nuchal line of the occiput, under cover of the *trapezius* and *sterno-cleido mastoid* muscles.

As the *splenii* of opposite sides diverge above from the ligamentum nuchæ at an angle of 80° , they leave between them an **intersplenial triangle**, wherein the *complexus* muscle, the occipital artery and the greater, and part of the lesser, occipital nerves appear.

The *splenius* is supplied by branches from the external divisions of the second, third, and fourth posterior cervical nerves. Branches from the same

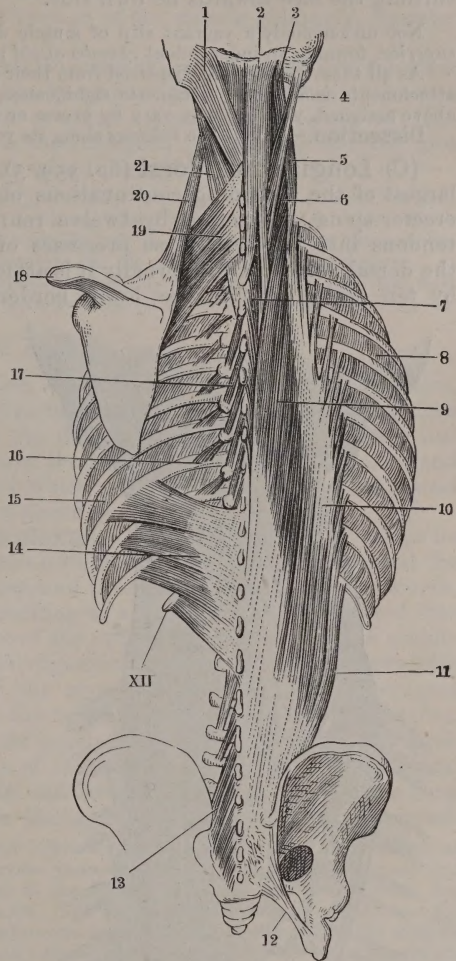


Fig. 358.—Third, fourth, and fifth layer of muscles of the back—1, splenius capitis; 2, 3, complexus; 4, longissimus capitis; 5, iliocostalis cervicalis; 6, longissimus colli; 7, semispinalis; 8, 15, external intercostal; 9, longissimus dorsi; 10, 11, iliocostalis; 13, 17, multifidus spinæ; 16, levator costæ; 19, serratus posticus superior; 20, serratus inferior; 21, splenius colli.

series below supply the *ilio-costalis*, each fascicle of which has generally a twig from the nerve of the segment below that into which it is inserted.

The two *splenii* conjointly retract, each muscle separately rotates, the head, turning the face towards its own side.

Not uncommonly a vagrant slip of muscle develops on the wrong side of the *serratus superior*, forming an independent *rhombo-atloid* muscle.

As all these muscles are displaced from their primitive positions, the number of vertebral attachments is of little metameric significance, and although most commonly they are as above assigned, yet they may vary by excess or deficiency.

Dissection.—Divide the *splenii* along its vertebral origin, and reflect it outwards.

(C) **Longissimus dorsi** (fig. 359, 3), the largest of the ascending continuations of the erector spinæ, is inserted by twelve rounded tendons into the transverse processes of all the dorsal vertebræ. Externally it is attached by ten fleshy slips to the lower borders of

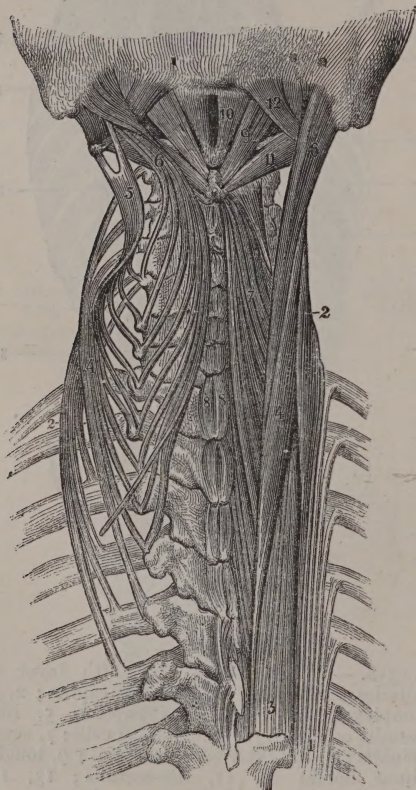


Fig. 359.—Muscles of fourth layer of nucha.

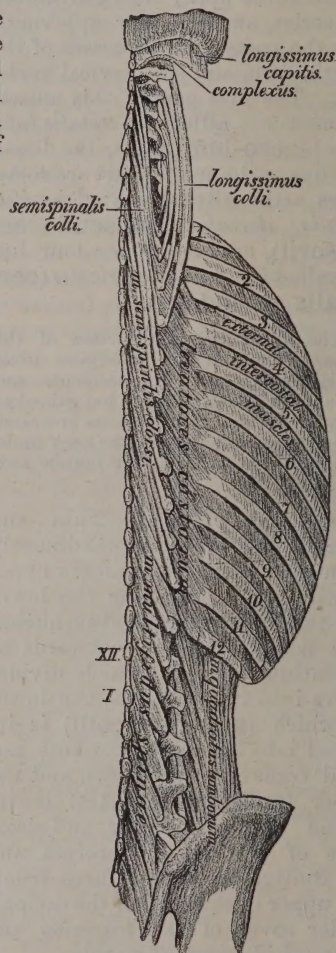


Fig. 360.—Muscles of the fifth layer.

the eight inferior ribs between their tubercles and angles, and into the lower border of the costal process of the first and second lumbar vertebræ extending outwards into the dorso-lumbar fascia. An accessory portion arises from the transverse processes of the upper five dorsal and from the tuberosities of the lower two cervical vertebræ, and, dividing into two

parts, is inserted by its outer portion (*longissimus cervicis* or *transversalis colli*—*ib.*, 4), into the transverse processes of the second to the sixth cervical vertebrae, and by its inner (*longissimus capitis* or *trachelo-mastoid*—*ib.*, 5, 6) into the mastoid process under cover of the *splenius capitis*. A tendinous intersection crosses this last portion of the muscle obliquely, opposite the fourth cervical spine.

(D) *Spinalis dorsi* consists of that superficial portion of the erector mass containing but little muscle, which arises by tendons from the spines of the two upper lumbar and three lower dorsal vertebrae. Ascending, it gives off nine tendons internally, the first of which is the strongest. These are inserted into the outer sides of the nine upper dorsal spines (fig. 357).

An ascending continuation from the third upper dorsal to the second to the fourth cervical spines (*spinalis cervicis*) is inconstant. A strong slip from the origin of the *spinalis* constantly blends with the *longissimus*, and must be cut in order to separate the muscles. The external branches of the dorsal nerves separate the *ilio-costalis* from the *longissimus*.

Dissection.—Raise and reflect these muscles, especially the *longissimus*, and the next layer is exposed, which is closely connected with the tendons of the *spinalis dorsi*.

FIFTH LAYER.

150. SEMISPINALIS is a stratum of long, obliquely ascending fascicles, extending from the first lumbar vertebra to the occiput. Its spinal part arises from the transverse processes of all the dorsal and of the last two cervical vertebrae, and is inserted into the sides of the spines of the upper six dorsal and lower six cervical vertebrae. The part whose insertion ends at the first dorsal spine is the *semispinalis dorsi*, the part above is the *semispinalis colli*.

The *semispinalis capitis* or *complexus* is large (fig. 357), and overlaps its neighbours, arising with the *semispinalis colli* from the upper six dorsal and the lower three cervical transverse processes, and from the tuberosities of the fourth, fifth, and sixth cervical vertebrae; ascending as a thick mass, it is inserted into the occipital bone below the inner part of the upper nuchal line. In the middle of its course, and at its origin, an inner digastric part (the *biventer cervicis*) is often segmented from the rest of the muscle, and is usually interrupted by a tendinous intersection opposite the spine of the sixth cervical vertebra, but the separation of this portion is not continued to the insertion. The *semispinalis capitis* is supplied by branches of the second, third, and fourth cervical nerves, the slips of the *semispinalis colli* and *dorsi* by branches which come from the nerve of the second segment below that into which each fascicle is inserted.

On removing the *semispinalis* the posterior branches of the spinal nerves are exposed, as they emerge backwards between the transverse processes, each dividing into external and internal divisions (fig. 104, p. 58). Of those in the dorsal region, the internal decrease, the external increase in size from above downwards. The former supply the *semispinales* and the deeper muscles, and the upper six give off cutaneous branches; the latter supply the muscles of the *erector* groups, and the lower six give off cutaneous branches. The lower seven cervical nerves resemble the upper dorsals, except that cutaneous branches seldom arise from the sixth, seventh, and eighth, and that the cutaneous branch of the third lies between the *semispinalis colli* and *semispinalis capitis*, while that of the second is very large (*occipitalis major*), and appears below and outside the *inferior oblique*, and pierces *semispinalis capitis* on its way to the scalp. The lumbar posterior nerves resemble the lower dorsal, and the upper three give off cutaneous branches from their external divisions. The inner branches lie in grooves on the lumbar vertebrae below the upper articular processes. Minute cutaneous filaments may, however, be demonstrated from the inner divisions of all spinal nerves.

Two large arteries appear in this dissection. The occipital lies at the upper part in the occipital groove behind the mastoid process, under the *splenius* and *longissimus capitis*, and ascends out of view through the intersplenic space into the scalp. In this second stage of the vessel it gives off two branches—(1) *A. princeps cervicis*, which descends inwards beneath the *semispinalis*, and sends off a superficial branch which runs under and is distributed to the *trapezius*, and a deeper, which passes downwards, and anastomoses with the deep cervical artery; (2) communicating branch, which crosses the *superior oblique* to join a muscular branch of the vertebral artery.

Cervicalis profunda.—This branch of the superior intercostal artery (§ 429) appears with the posterior division of the eighth cervical nerve beneath the transverse process of the seventh cervical vertebra and turns upwards, supplying contiguous parts and joining the *princeps cervicis* above. Its vein often receives a large superficial tributary which pierces the *trapezius* and *splenius* (vena azygos colli) close to the first dorsal spine. Posterior branches of the intercostal and lumbar arteries accompany their nerves in each intervertebral space below.

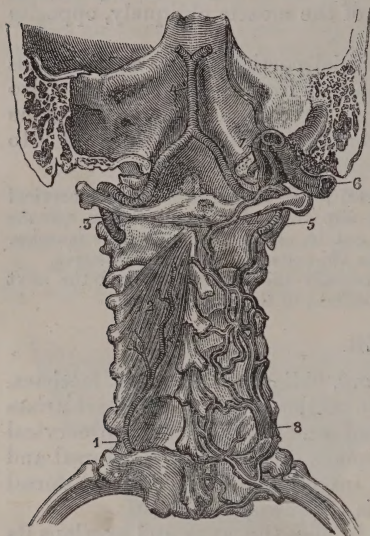


Fig. 361.—Portion of multifidus spinæ of cervical region (2) and posterior vertebral veins (8); 5, vertebral artery.

dorsal region it is with difficulty separable from the *semispinalis*. The strongest cervical fascicle is that which passes from the fifth cervical vertebra to the spine of the axis.

151. MULTIFIDUS SPINÆ (fig. 360).

—A thick layer of oblique transversospinal muscular fascicles, each of which passes over only two vertebræ. These can be artificially separated from each other, but it is better to consider it as a continuous mass, very thick below, thinning above, arising from the articular processes of the sacrum as far downwards as the fourth foramen, from the accessory and articular processes of the lumbar vertebræ, from the tuberosities of the transverse processes of the dorsal, and from the tuberosities of the cervical vertebræ as far upwards as the third. The tendinous and fleshy fascicles are inserted into the lateral ridges of the lower edge of the lumbar and dorsal spines, into the tubercles at the lower edge of the laminae of the cervical vertebræ, and into the lower and outer surface of each subdivision of the cervical spines as far as the fourth. In the upper

SIXTH LAYER.

152. DEEP SHORT MUSCLES (*Rotatores spinæ*).—On removing the *multifidus* from the dorsal region small transverse bundles of fleshy and tendinous fibres are exposed, which pass from the root of each transverse process posteriorly, to the lower edge of the lamina of each vertebra above. There are generally ten of these, which extend from the second to the eleventh dorsal vertebræ.

A few fascicles occasionally skip a vertebra, and constitute *rotatores longiores*, but these are inconstant.

Inter-transversales are weak muscles in the neck and loins, passing from the transverse process below, to the corresponding process above. In the dorsal region these are represented by fibrous cords, in the lower four of which some fleshy fibres may exist. In the lumbar region they are fine, round bundles between the transverse (accessory) processes.

The so-called *anterior inter-transversales* are cervical and lumbar intercostals.

Inter-spinales (fig. 359, 8) are vertical short muscles, one on each side of the interspinous ligament between the spinous processes. They are distinct between the cervical vertebræ from the third to the seventh, between the seventh cervical and first dorsal, between the first to the third, and the tenth to the twelfth dorsals, and appear as thin, flat muscles on each side of the lumbar.

At the uppermost portion of the neck these short muscles have become specialised as follows, to move the head :—

Rectus capitis posterior major (fig. 359, 9).—The largest of these arises from the side of the spine of the axis, and is inserted into the outer part of the inferior nuchal line and into the rough area below it. It runs obliquely upwards and outward.

Rectus capitis posterior minor (fig. 359, 10) is a fan-shaped muscle, deeper, smaller, and internal to the last, arising narrow from the posterior tubercle of the atlas, and inserted into the space below the inner end of the inferior nuchal line, but not extending as far as the edge of the foramen magnum.

Obliquus capitis inferior runs very obliquely from the spine of the axis to the lower and back part of the transverse process of the atlas (fig. 359, 11).

Obliquus capitis superior, also oblique, runs from the upper surface of the transverse process of the atlas to the space between the splenial area and the inferior nuchal line, above and external to the *rectus capitis major* (fig. 359, 12).

The *rectus major* and the two *oblique* muscles bound a **vertebral triangle**, in which the posterior arch of the atlas can be seen when the space is dissected. The bone is here grooved above for the vertebral artery. Emerging between the artery and the bone is the very short posterior branch of the first cervical or suboccipital nerve, which divides into an internal branch to the *recti*, a descending branch to the *inferior oblique* which joins the second cervical nerve, an ascending branch to the *superior oblique* and one to the *complexus*. There is no branch corresponding to the external branch of the lower nerves.

The *superior oblique* belongs to the series of the *multifidus*. The *inferior oblique* is a dismemberment of the *rectus major* which is an *interspinalis*.

The *rectus capitis lateralis* (§ 490) is in series with the *intercostal* muscles.

Having removed the muscles of the back, the ligaments of this region which appear superficially should be examined (§ 76, *et seq.*)

153. POSTERIOR SACRAL NERVES.—Upon the back of the sacrum the five posterior sacral nerves can now be fully traced. The lowest emerges between the sacrum and coccyx, joins the fine ascending posterior branch of the coccygeal nerve below and that of the fourth sacral above, and sends branches to the surrounding parts. The three upper sacral nerves divide under the *multifidus* into outer and inner branches, the latter end in that muscle, the former, larger, are united by a series of uniting filaments into loops, from the convexity of which two trunks pass through the sacro-iliac and sacro-sciatic ligaments to be distributed to the skin over the tuber ilii.

Sacro-coccygeus posticus.—A rudimentary extension of the erector spinæ is usually traceable downwards as a fibrous band, in which sometimes muscular fibres are detectible, arising from the sides and back of the fourth and fifth sacral vertebrae and inserted into the back of the coccyx. This is the rudiment of the *levator caudæ* of quadrupeds.

154. DORSAL SPINAL VEINS (fig. 361).—In this dissection a plexus of veins is exposed, ramifying beneath the *multifidus* upon the laminae, and communicating by spinal branches with the veins of the vertebral canal through the interlaminar ligaments.

Dissection.—Divide with a spinal saw the laminae of all the vertebrae close to the articular processes, and remove the spines and hinder wall of the neural arches so as to exhibit the membranes of the spinal cord. On removing a quantity of loose fat and watery connective tissue which fills the cavity that is homologous with the interdural space, the *theca vertebralis* or fibrous sheath of the spinal cord is exposed. Through this membrane, which is the *spinal dura mater*, the spinal nerves pass out, each to escape through the corresponding intervertebral foramen. The two roots of each nerve pierce the membrane by separate holes, from each of which a sheath is prolonged, but these roots unite externally at the ganglion on the hinder root. Having examined the external connections of this membrane, and the brain having been previously removed, it is advisable to dissect the *theca* with its contents out from the spinal canal, cutting with curved scissors each nerve at the intervertebral foramen, and the cord can then be placed in spirit for subsequent examination. It is a good plan to mark with an aniline pencil upon the membrane before removal, lines indicative of the levels of the seventh cervical, twelfth dorsal, second and fifth lumbar vertebrae to be guides in the study of the detached cord. Before placing in spirit lay open the *theca* to allow the contained textures to harden.

The sac of *dura mater* extends down to the third sacral vertebra, and internally is connected to the surface of the spinal cord by fine *subdural* filaments of connective tissue,

which are most numerous in the cervical and lumbar regions. Similar cords tie the nerves of the cauda equina to the sheath. An intimate connection is also preserved laterally by a flat band of pia mater, the **ligamentum denticulatum**, which is attached by a long straight border to the pia mater, investing the side of the cord between the anterior and posterior roots of the nerves, and externally by a toothed edge to the inner side of the dura mater. This margin has twenty-one teeth attached to the bridge of dura mater between the exits of the nerve roots, the last tooth being attached above the first lumbar nerve, below which the ligament continues as a membranous margin to the **conus terminalis** of the cord. The first tooth is attached above the hole for the vertebral artery, and in front of the spinal accessory nerve. This ligament is sheathed loosely by the arachnoid membrane whose endothelium is continuous into the endothelium lining the dura mater.

Beneath the dura mater is a very thin loose connective layer, the arachnoid, separated from the dura mater by a very slight subdural space, but including a wide sub-arachnoid space in which the spinal cord is suspended, surrounded by the serous cerebro-spinal fluid of the space, and only attached (1) by a median dorsal septum posticum, which is interrupted above, though continuous below; (2) laterally by the ligamentum denticulatum. The anterior roots of the nerve freely traverse the front part of the space; the posterior are tied together by an interrupted membrane.

Within the spinal canal and on the back of the theca vertebralis there is a close plexus of veins, the postero-internal plexus, whose main trunks are longitudinal on the inside of the articular masses. These are joined by transverse branches with each other, and with the still larger antero-internal plexus, which lies on the backs of the bodies of the vertebrae. The main stems of this latter are two long veins which pass from end to end of the vertebral canal on the roots of the pedicles of the vertebrae. Across the back of every body these are joined by a cross branch. Each of these anterior transverse branches receives the basi-vertebral vein from the cancelli of the vertebral body. The blood from this system is emptied by branches through every intervertebral canal into the vertebral, intercostal, lumbar, and sacral veins respectively. The whole system is extrathecal, but within the periosteum of the canal, and therefore on the same horizon as the system of cerebral sinuses (fig. 472).

THE UPPER EXTREMITY.

155. The upper limb is joined to the trunk by the sterno-clavicular joint and by ten muscles. Four of these (*trapezius*, *latissimus dorsi*, *rhomboideus*, and *levator anguli scapulae*) have been already seen in the back; two (*sterno-mastoid* and *omo-hyoid*) will be found in the neck (§§ 409, 415); and the four others which lie on the front and side of the thorax should next be dissected.

156. **REGIONS OF THE THORAX.**—For clinical purposes the thoracic wall may be mapped into three median and seven pairs of lateral regions. The median are :—(1) **suprasternal**, corresponding to the pre-sternal notch; (2) **upper sternal**, above the level of the third costal cartilage, corresponding to the origins of the great vessels; (3) **lower sternal**, corresponding to the heart. The lateral are :—(1) **supraclavicular**, above the inner half of the clavicle, corresponding to the apex of the lung; (2) **clavicular**, behind the inner half of the clavicle; (3) **infraclavicular**, below the clavicle and above the third rib; (4) **mammary**, between the third and the sixth ribs; (5) **infra-mammary**, below the sixth rib; (6) **axillary**, between the anterior and

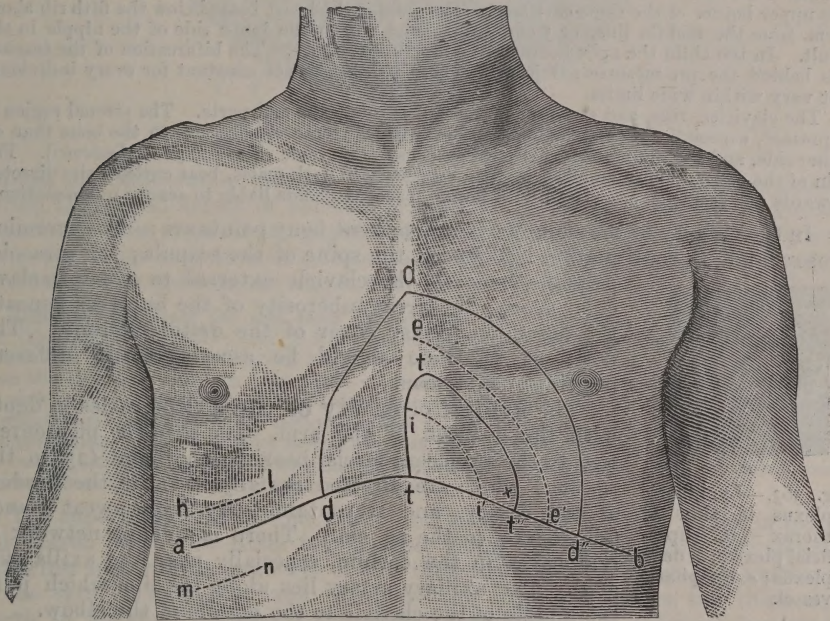


Fig. 362.—Surface of thorax, showing areas of cardiac dullness—*h*, *l*, lower level of right lung in forced expiration; *m*, *n*, ditto in forced inspiration; *i*, *i'*, limit of margin of left lung in forced inspiration; *e*, *e'*, ditto, in forced expiration.

posterior axillary folds as far down as the fourth rib; (7) **infra-axillary**, between the same meridian lines as far as the border of the thorax. Four vertical lines are useful as guides :—(1) **sternal**, vertical lines dropped from the sternal ends of the clavicles, one on each side of the sternum; (2) **mammillary**, the line drawn through the nipple; (3) **parasternal**,

midway between the first and the second, and separating the median from the lateral regions; (4) **axillary**, the vertical line drawn through the anterior fold of the axilla.

These lines and spaces should be mapped out on the skin with an aniline pencil. When the mammae are pendulous the mammillary line may be taken as corresponding to the perpendicular dropped from the middle of the clavicle.

The thorax should emit a clear note on percussion, except in the **region of the heart** (fig. 362, d, d) which lies *below* the line of the second costal cartilage, *to the left of* a vertical line drawn downwards from the sternal end of the right clavicle, *to the right of* an oblique line drawn from the left second costal cartilage, to the upper edge of the sixth cartilage 9 cm. from the middle line, and *above* a line from this point to the lower edge of the cartilage of the right fifth rib. The **area of greatest cardiac dulness** (fig. 362, t, t', t''), where the heart is uncovered by the edge of the lung, is included in a triangle bounded by the median line, by a line drawn from this point to the fourth costal cartilage to the point of junction of the left fifth rib and cartilage, and by the horizontal line drawn from this point to the median line. The space between d, d, d, and t, t, t, emits a muffled note on percussion.

The right auriculo-ventricular opening is behind the middle of the sternum opposite the fourth costal cartilage; the left is behind the left border of the sternum at the top of the cartilage of the fourth rib. The aortic opening is to the left of the middle line opposite the lower border of the third costal cartilage; the pulmonic orifice is at the left of the sternum opposite the upper border of the same cartilage. The apex of the heart beats below the fifth rib about 9 cm. from the middle line, or 5 cm. below, and 2·3 to the inner side of the nipple in the adult. In the child the apex beats on the fourth interspace. The bifurcation of the trachea lies behind the pre-mesosternal joint. These points are not constant for every individual but vary within wide limits.

The clavicles, ribs, and sternum can be felt through the soft parts. The sternal region is depressed, especially in the female; its skin is thick, more closely tied to the bone than on either side, and the pre-mesosternal joint feels as a transverse ridge (*Angulus Ludovici*). The skin of the sternal and mammary regions, especially in dark males, bear curled hairs directed upwards and inwards, associated with large sebaceous glands liable to acnous inflammation.

In the vicinity of the shoulder the prominent bony points are:—The acromion process and its continuation backwards, the spine of the scapula; the coracoid, palpable beneath the clavicle external to the infraclavicular space; the great tuberosity of the humerus beneath the acromion, under cover of the deltoid muscle. The positions of these should be ascertained in different positions of the arm.

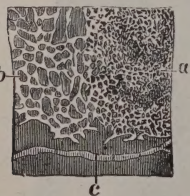


Fig. 363.—Lymphatic plexus in skin of thorax — *a*, superficial plexus; *b*, deep plexus; *c*, lymphatic vessel.

The **armpit or cavity of the axilla** varies in depth with the position of the arm. Its skin is pigmented, tied to the subjacent fascia, bearing long hairs (25 to the sq. cm.) which are directed radially towards the borders of the cavity, and it contains very large sweat glands (about 110 to the sq. cm.) There is a dense network of lymphatics in the corium, especially near the axilla (fig. 363). The axillary artery lies along the line which joins the middle of the clavicle to the middle of the elbow.

Over the clavicles the skin is smooth, thin, hairless and loosely adherent. In general the epidermis on the front and sides of the thorax is thin, the underlying papillae being about 0·7 mm. long, and the corium about 3·5 mm. thick.

157. THE MAMMARY GLAND is placed in the female between the axilla and sternum, and extends from the third and sixth ribs on each side. In the female it is a broadly conical mass with an oblique elliptic base before it becomes functional; but after lactation it frequently becomes pendulous, its normal condition in the adult females of dark races. A little below its mid-point,

usually opposite the fourth intercostal space and about 12 cm. from the middle line is the *nipple* or *mammilla* (fig. 364), a wart-like eminence, cylindroid, conical, clavate, or flat, on whose smooth or papillose surface the milk ducts open. The skin of the nipple is pigmented and its base is surrounded by a ring of coloured skin, the *areola* (*ib.*, 3), 3.5 cm. wide in the female, 2.5 in the male,

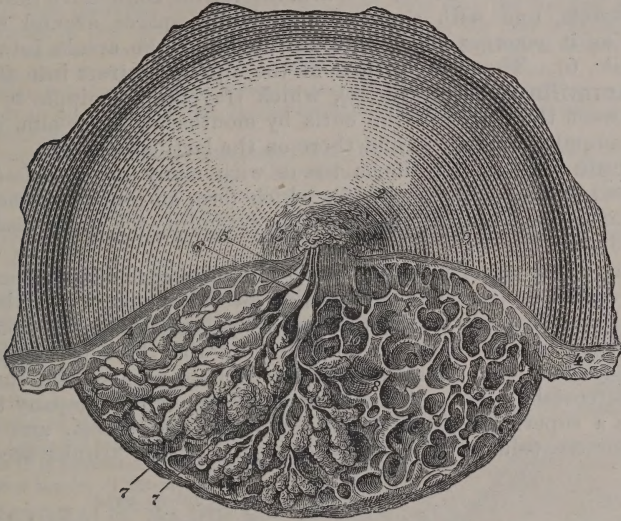


Fig. 364.—Mammary gland, the lower half dissected.

pinkish and moderately smooth in the young female, but becoming brown during the second month of the first pregnancy, and never resuming its former appearance. In some of its papillæ there are touch corpuscles and between them are large and branched sebaceous glands (**Montgomery's glands**), whose secretion protects the nipple from the juices of the child's mouth (*ib.*, 2).

Dissection.—Draw the arm from the side and divide the skin, (1) along the median line, (2) along the clavicle; and (3) from the metasternum to the hinder fold of the axilla. Reflect this flap outwards, having previously made a circular incision around the areola to leave the nipple in situ. A thin plane of muscular fibres, the *platysma*, descending from the neck, to be inserted into the infraclavicular skin appears over the clavicle, under cover of which three supraclavicular nerves descend in the superficial fascia to supply the supra-mammary skin. The innermost is the shortest and supplies the skin over the presternum, the outermost ends in the anterior fold of the axilla. A few small communications exist between these nerves and the anterior cutaneous.

The superficial fascia at the upper and medial parts of the region is tough and elastic with but little fat, pierced along the sternal line by slender **anterior cutaneous** branches of the intercostal nerves which pass outwards to the skin. The second and third are the largest in males, the third and fourth in females. Anterior intercostal branches of the internal mammary vessels emerge with these, the second, third, and fourth of which are distributed to the mammary gland. In the deep layer of the axillary skin there are bands of unstriated muscle, overlying the sweat glands. Both these and the glands are visible to the naked eye.

The **mammary gland** as now exposed is a compound racemose gland, and appears in the female as an uneven mass, flat beneath, convex superficially. When the fat (fig. 364, 4) which surrounds it is removed, no easy task, the gland appears to be enveloped in a tough laminated capsule of the superficial

fascia, sending processes into it, the *suspensory ligaments of Cooper*, which are continuous with the interstitial tissue of the organ and contain fat in their meshes (*ib.*, 8, 10).

The gland tissue consists of 20-22 pinkish-white, firm, irregular lobes, each consisting of the branches of a **lactiferous duct** (*ib.*, 7), whose terminal radicles are tubular acini united together by a firm interstitial connective tissue traversed by blood-vessels, and with a network of lymph spaces around each acinus. Each duct as it emerges from its lobe dilates at the areola into a fusiform **ampulla** (*ib.*, 6). These, at the base of the nipple, contract into about sixteen narrow **mammillary ducts** (*ib.*, 5), which traverse the nipple to open on its surface between the ridges of the cutis by mouths about .6 mm. in diameter. Secondary ampullæ occur here and there on the lactiferous ducts.

The **nipple** consists of retiform tissue with many fine vessels (fig. 365, 5), and unstriped muscular fibres (*ib.*, 6), which form an imperfect sheath around the ampullæ and mammillary ducts, even extending for some distance on the lactiferous ducts.

The lobes of the gland are nearly independent of each other, hence mammary abscesses are often multilocular and require several openings. The blood-vessels of the gland are many and small; they enter its margins, and do not accompany its ducts. The upper lobes are supplied by the thoracico-acromial artery, the outer by the long thoracic and external mammary, the inner by the anterior intercostals. Some of the veins are deep, and accompany the arteries, others form a superficial circle of anastomosis in the areola, and end in the superior thoracic vein. Some of the emerging lymph trunks accompany the

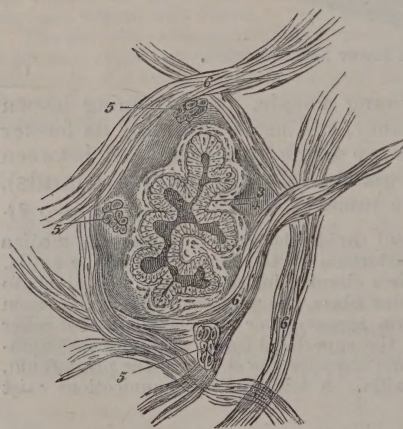


Fig. 365.—Section through portion of mam-milla, showing ampulla cut through, and the unstriped muscular interlacement.

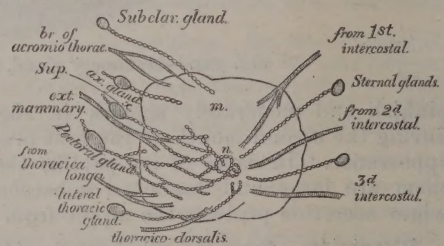


Fig. 366.—Diagram of blood-vessels and lymphatics of mammary gland.



Fig. 367.

intercostal veins to the glandulæ sternales of the first, second, and third intercostal spaces, but they mostly pass into two large glands in the axilla behind the edge of the pectoral muscle. Those from the areola and nipple pass to a gland nearer to the clavicle (fig. 366, *x*). The nerves are derived from the third, fourth, and fifth intercostals, and accompany the arteries.

The gland weighs about 140 grammes, increasing to 260 during lactation. Its volume when quiescent is about 220 c.cm., its greatest length, parallel to the fibres of the great pectoral, is nearly 13 cm., its breadth 11 cm., and its thickness 5.5 cm.

Development.—In a seventh week fœtus the epidermis of the mammary region has

thickened, and solid columns of its deep cells have begun to project into the underlying cutis (fig. 367, *d*), from which, in turn, a few processes extend into the thickening epidermis. Around this area is a marginal ridge, the **primary mammary fold** (fig. 367, *pmf*). The columns of epidermal cells elongate radially, become clavate (*g*) and branched, so forming a definite mass, and the space within the mammary fold becomes the areola. The male gland continues in this state; but in the female the gland grows, and at birth some of the columns have become modified into branching tubular ducts. The nipple develops in the third year, and true glandular acini form at the ninth year near the margins of the lobes. These are originally in the form of solid cylinders, but during the first pregnancy the acini grow rapidly in number, and, as the epithelium proliferates, the central cells of each acinus become fat-laden, and are cast off in the first milk as *colostrum corpuscles*.

When lactation is ended the gland tissue undergoes fatty degeneration.

The nipple is an up-growth of the dermis around the ducts. The areola is supplied by the second intercostal artery.

The adult mammae are usually unsymmetrical, the left being generally the larger and higher. The male gland is rudimental, with rudimental ducts and a few solid unbranched acini. The gland is an extreme specialisation of a series of dermal sebaceous glands.

A layer of loose-meshed submammary connective tissue underlies the gland and allows it to glide a little on the *pectoral* muscle. This tissue is beneath the capsule, hence submammary abscesses do not burrow through, but point at the side of, the gland. Occasionally this tissue becomes so loose in patches as to appear like a bursa, and it may be the seat of hygro-matous tumours.

Dissection.—Remove the gland and the sheath of the *great pectoral* muscle. Note the positions of the vessels divided, and leave the fascia of the axillary floor undisturbed, as it is attached to the inner edge of the lower border of the muscle.

158. PECTORALIS MAJOR is functionally a triangular muscle, and forms the front fold of the axilla. It arises in three portions—(1) *clavicular*, from the front of the inner half of the clavicle and sternoclavicular capsule; (2) *superficial sternocostal*, from the front of the sternum for nearly half its breadth, and from the thoracic part of the sheath of the *rectus*; (3) *deep sternocostal*, beneath the last from the sternal ends of the cartilages of the five upper ribs. These parts are occasionally quite distinct from each other.

It is inserted by a bilaminar tendon into the outer lip of the bicipital groove under cover of the edge of the *deltoid*. The clavicular part is superficial, separable, and inserted as low down as the insertion of the *deltoid* with which it is continuous below, but these muscles are separated above by an **infraclavicular triangle** containing the cephalic vein and the humero-thoracic artery. The lowest of the clavicular fibres are inserted into the brachial fascia. The deep sternocostal fibres ascend the highest, so the tendon appears twisted; its superficial lamella is derived from the first and second part, while the deeper comes from the third part.

The deep surface of the tendon near the insertion is crossed by vertical fibres derived from the external intermuscular septum, and attached above to the great tuberosity and

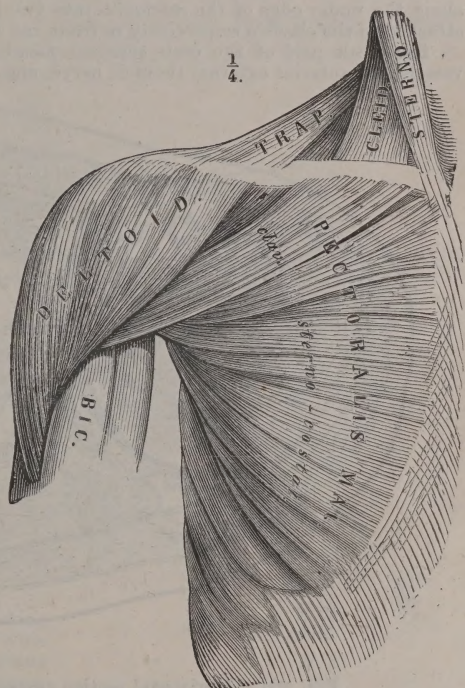


Fig. 368.—Superficial muscles of the anterior thoracic region.

mus dorsi; it is thicker and hangs lower than the anterior, and where it and the front wall converge externally the angle is rounded by the *biceps* and *coraco-brachialis* muscles. Its apex above communicates with the supraclavicular cervical triangle by a three-sided **cervico-axillary passage**, bounded by the first rib, the clavicle, and the upper edge of the scapula, through which the axillary vessels and nerves pass, and from which they carry down an indefinite funnel-like areolar sheath. Its base below is concave, formed by the axillary fascia, which is attached in front to the lower and inner border of the *greater* and to the lower edge of the sheath of the *lesser pectoral muscle*; it is continuous externally with the fascia of the arm, internally with the sheath of the *serratus magnus*, and posteriorly with the upper edge of the sheath of the *latissimus dorsi*.

Dissection.—Detach and remove this fascia, avoiding the cutaneous nerves which pierce it, and having thus opened the axilla remove the fat and areolar tissue which are closely packed round the more important contents, beginning posteriorly where the subscapular artery and long subscapular nerve form convenient guides to the deeper parts.

Imbedded in these tissues there are usually twelve **lymphatic glands** (fig. 370). Three lie along the lower edge of the *great pectoral*, one close to the humerus receiving the cutaneous brachial lymphatics, one close to the thoracic wall, and one intermediate, receiving mammary and superficial thoracic lymphatics. Two lie above these behind the *great pectoral* and receive the lymphatics of the areola and nipple. Two overlie the costo-coracoid membrane close to the cephalic vein receiving lymphatics from the shoulder, and three rest on the axillary vein receiving the deep brachial lymphatics. One upon the subscapular artery behind collects the lymph vessels of the hinder wall of the cavity, and one lies on the *latissimus dorsi* close to the scapular quadrilateral space. The efferent lymph vessels from all these ascend on the axillary vein, having crossed the artery, and enter the neck by four trunks (§ 420), each gland receives a small artery, an indirect branch of the axillary.

Dissection.—Remove the glands, noting their relations to the underlying parts. Divide the rest of the *great pectoral* by a vertical incision 10 cm. from its insertion and reflect it, leaving in place the artery and nerves which enter it over the *lesser pectoral*, which should next be cleaned.

160. PECTORALIS MINOR (fig. 371, 5), triangular, arises by thin flat tendinous slips from the upper edges of the third, fourth, and fifth ribs external to their cartilages. Two slips usually arise from the fourth rib. Ascending outwards it is inserted by a narrow flat tendon into the upper and inner edge of the coracoid processes, and by an expansion into the origin of the *coraco-brachialis*. The anterior internal thoracic nerve supplies it (8 c.), and sends some filaments through the muscle, which, together with the pectoral branches of the thoracico-acromial artery, separate it from

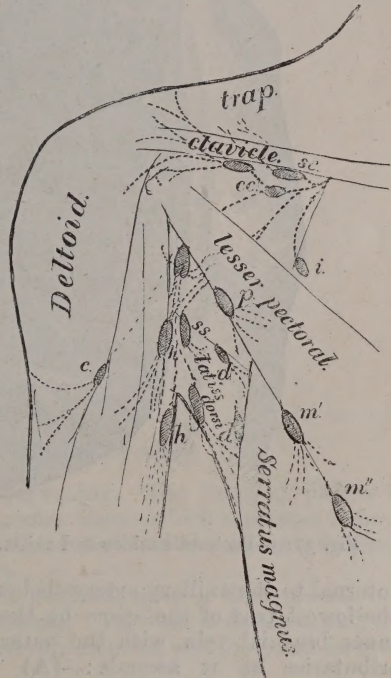


Fig. 370. — Diagram of the lymphatic glands of the axilla.

the overlying *great pectoral*, while the long thoracic artery runs along its lower border. This muscle depresses the shoulder. Its extreme fibres include an angle of 30° , whose resultant ascends at an angle of 45° in the line joining the sternal end of the fourth rib to the coracoid process. The *lesser pectoral* is a deep delamination of the *great pectoral*.

161. THE AXILLARY VEIN (fig. 371, 20) is the most superficial of the great vessels in the axilla, and ascends behind the *pectoral* muscles in front and

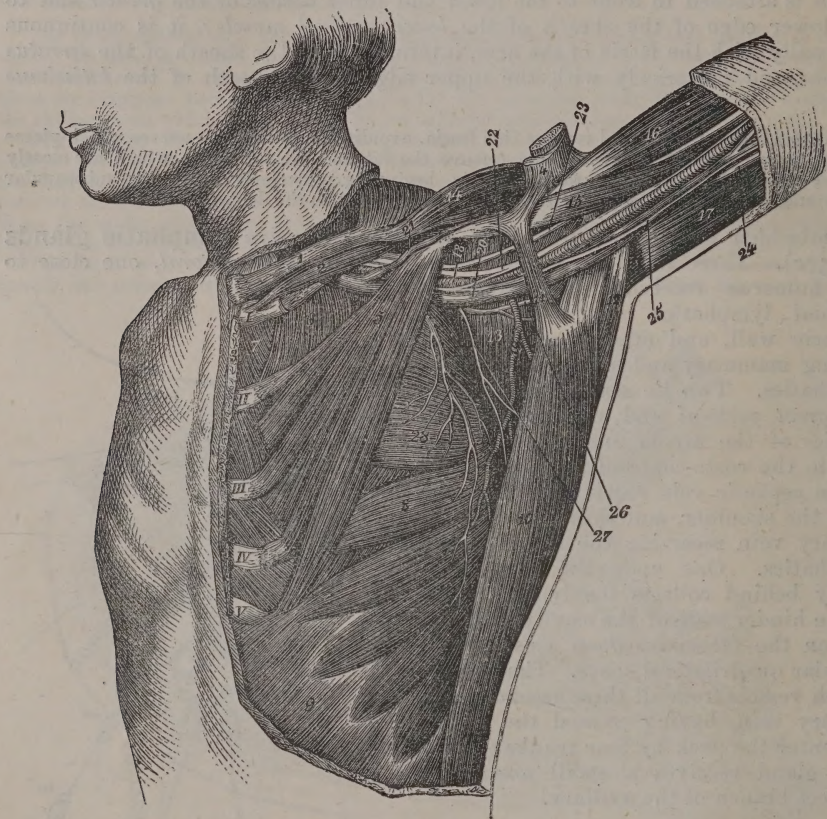


Fig. 371.—Pectoralis minor and axilla. The slip marked 11 is an anomalous muscle.

internal to the axillary artery (below it when the arm is raised). It begins at the lowest part of the space by the junction of the combined basilic vein and inner brachial vein with the outer brachial vein, and receives the following tributaries as it ascends:—(A) Below the *lesser pectoral*—(1) posterior circumflex; (2) subscapular; (3) anterior circumflex; (4) inferior thoracic veins; (B) above the *lesser pectoral*—(5) superior thoracic; (6) cephalic; (7) thoracico-acromial veins. Each of these veins, except No. 6, accompanies its artery. There is a single valve at the mouth of each branch, and two paired valves in the main trunk. It becomes the subclavian vein above the lower edge of the first rib (§ 420).

Dissection.—Ligature the vein at either end and remove it, having noted its relations to the artery and the passage of the anterior internal thoracic nerve between these two vessels. Leave for the present the *lesser pectoral* undivided.

162. THE AXILLARY ARTERY (figs. 371, 18; 372) is the continuation of the subclavian (§ 419) from the lower border of the first rib, and it changes its name at the lower edge of the *teres major* tendon, becoming brachial (p. 288). It is divided into three unequal stages, the first above the upper edge of the *lesser pectoral*, the second behind and the third below that muscle. These average respectively 2.5, 3, and 8 cms. in length.

In the **first stage** it lies under the skin, *platysma*, supraclavicular nerves, clavicular part of the *great pectoral*, and the costo-coracoid membrane; it is crossed by the external anterior thoracic nerve, cephalic and thoracico-acromial veins, and the axillary lymphatic trunks. Its vein lies *internal*, overlapping

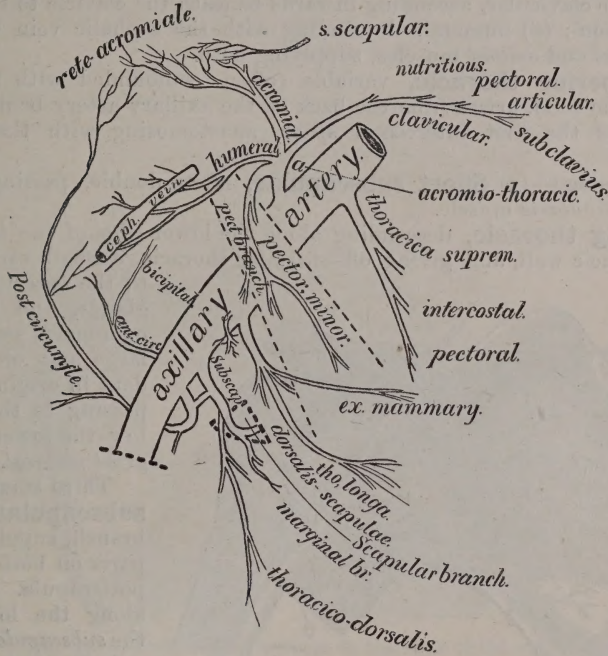


Fig. 372.—Diagram of branches of axillary artery.

it, the anterior internal thoracic nerve intervening. The brachial plexus is *external*, and the artery lies on a plane of areolar tissue which separates it from the first intercostal muscle, the second and third teeth of the *serratus magnus*, the posterior thoracic nerve, and second rib.

The **second stage** lies under the two *pectorals*, upon a thick areolar bed which separates it from the *subscapular* muscle. Its vein is *internal*, and the three cords of the brachial plexus are respectively *external*, *posterior*, and *internal* to it.

The **third stage** belongs to the arm, not to the axilla, and should properly be described as part of the brachial. It is covered by skin, fascia, and the lower edge of the *great pectoral*, which guides the surgeon to find it; and is crossed by the inner head of the median nerve, and by the outer brachial vena comes. *External* to it are the *coraco-brachialis* (which overlaps it, and whose edge forms a good guide to it), the musculo-cutaneous and median nerves. *Internal* are the ulnar and internal cutaneous nerves and its own vein. It lies on the *subscapularis*, the circumflex nerve, the tendons of the *latissimus dorsi*, and *teres major*, and the musculospiral nerve.

The artery receives vasomotor nerves from the first dorsal ganglion of the sympathetic. The branches of the axillary artery are variable in order and size, and differ in the sexes. They are :—

First stage—(1) **Thoracico-acromial**, a short ascending trunk, dividing into four branches as it pierces the costo-coracoid membrane—(a) pectoral, lying beneath the *great pectoral* and over the *lesser*, supplying both, and sending in the female a large mammary branch through the former; (b) acromial, ascending above the coracoid process to the surface of the acromion, where it takes part in the formation of the arterial rete acromiale, a network formed by anastomosing branches of this, the suprascapular and posterior circumflex arteries; (c) clavicular, ascending inwards beneath the clavicle to the soft parts of this region; (d) humeral, descending with the cephalic vein between the *great pectoral* and *deltoid* muscles, supplying both.

(2) **Superior thoracic**, variable (often confounded with the pectoral branch of the last), arises from the back of the axillary artery behind the vein, and supplies the first intercostal space, anastomosing with the intercostal vessels.

Second stage—(3) **Short subscapular**, often double, passing backwards to the *subscapularis* muscle.

(4) **Long thoracic**, descending along the lower edge of the *lesser pectoral* to the thoracic wall, and giving off—(a) alar thoracic, a small variable branch

to the anterior lymphatic glands, and (b) external mammary, small in males, large and often independent in origin in females, passing to the gland below the lower edge of the *great pectoral*.

Third stage—(5) **Long subscapular**, the largest branch, supplying the soft parts on both sides of the postscapula. It descends along the lower edge of the *subscapularis*, and after a short course divides into two branches—(a) *dorsalis scapulae*, which cannot be traced fully until the dissection is farther advanced (p. 284); it sinks into the subscapular triangle between the *subscapularis* muscle above, the *teres major* below, and the long

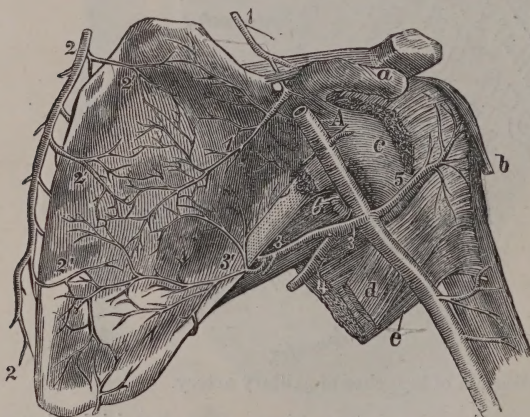


Fig. 373.—Dissection of subscapular arteries—A, axillary artery having behind it c, the capsule of the shoulder, as the *subscapularis* muscle has been removed, its cut border appearing under a, the coracoid process; 1, suprascapular artery, § 427; 2, posterior subscapular, § 425; 3, subscapular; 3', its deep subscapular branch; 4, posterior circumflex; 5, anterior circumflex; e, *teres major*.

head of the *triceps* externally. Here it gives off a deep subscapular branch which sinks beneath that muscle and ramifies on the bone, sending a branch along each of the costal ridges of the subscapular fossa. From the uppermost branch arises the ventral nutrient artery of the scapula and the superior articular artery of the shoulder. Having wound round and grooved the axillary edge of the scapula, the *dorsalis scapulae* ascends beneath the *teres minor* and *infraspinatus*, anastomosing in the substance of the former muscle with a branch of the posterior circumflex. Under the latter it ends by dividing into three branches—an ascending, which anastomoses with the

infraspinous artery, a transverse and a descending, which anastomose with the posterior scapular.

(b) *Thoracico-dorsalis* descends on the edge of the *latissimus dorsi* and *teres major* muscles, which it supplies, to the side wall of the thorax, where it ends in the *serratus magnus*. A small posterior branch descends on the ventral edge of the *teres major* to the inferior angle of the scapula, and communicates with the descending branch of the last and of the posterior scapular.

(6) **Anterior circumflex** (to be subsequently dissected, p. 286) arises from the outer side of the axillary artery above the *latissimus dorsi*, and passes in front of the surgical neck of the humerus under the *coraco-brachialis* and *biceps*. In the bicipital groove it sends upwards an anterior articular branch to the shoulder-joint. It ends beneath the *deltoid*, sending nutrient branches to the head and lesser tuberosity of the humerus, and a descending branch to the insertion of the *great pectoral*.

(7) **Posterior circumflex** (much larger and subsequently to be traced, p. 284) arises from the hinder and inner surface of the axillary artery and sinks with the circumflex nerve through the quadrilateral space bounded by the humerus externally, the *triceps* internally, the *subscapularis* above, and the *teres*

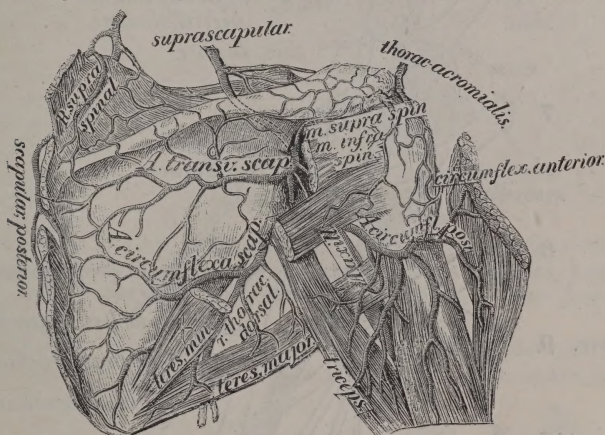


Fig. 374.—Dissection of arteries on the back of the scapula.

major below. It terminates beneath the *deltoid* in a series of radial branches supplying that muscle, having previously given off (a) an ascending branch to the *teres minor*, (b) a descending branch to the long head of the *triceps*, (c) nutrient branches to the greater tuberosity of the humerus, (d) posterior articular branches to the shoulder, (e) branches to the rete acromiale, and (f) an anastomotic branch to join the superior profunda (p. 288).

163. SUBCLAVIUS (fig. 371, 2) is a small penniform muscle, representing the second pectoral of the bird, and exposed by removing the costo-coracoid membrane. It arises by a strong tendon from the upper surface of the first rib close to its cartilage, and ascends obliquely outwards at an angle of 25° . Its fibres, expanding, are inserted into the subclavian impression of the clavicle. Its nerve (5 c.) enters its deep surface near its tendon. It fixes and depresses the clavicle.

Dissection.—Divide the *lesser pectoral* three inches from its insertion, and (the lower part of the neck having been dissected, § 418) saw through the clavicle or disarticulate its sternal end, draw the arm out from the side and clean the brachial plexus as it emerges between the *scaleni* muscles.

164. The BRACHIAL PLEXUS is formed by the unions of the united lateral

muscular and cutaneous branches of the anterior branches of the fifth, sixth, seventh, and eighth cervical, and the first dorsal nerves. The first pair unite and form the **uppermost trunk**, the fifth having previously received a descending branch from the fourth. The seventh runs by itself as far as the level of the clavicle, forming a **middle trunk**, and the lowest two unite on the first rib to form the **lowest trunk** as they leave the shelter of the scalenus anticus.

Each trunk splits into an **anterior** and a **posterior division**. The anterior divisions of the uppermost and middle trunks join behind the clavicle and form the **outer cord** of the plexus. The anterior division of the lowest

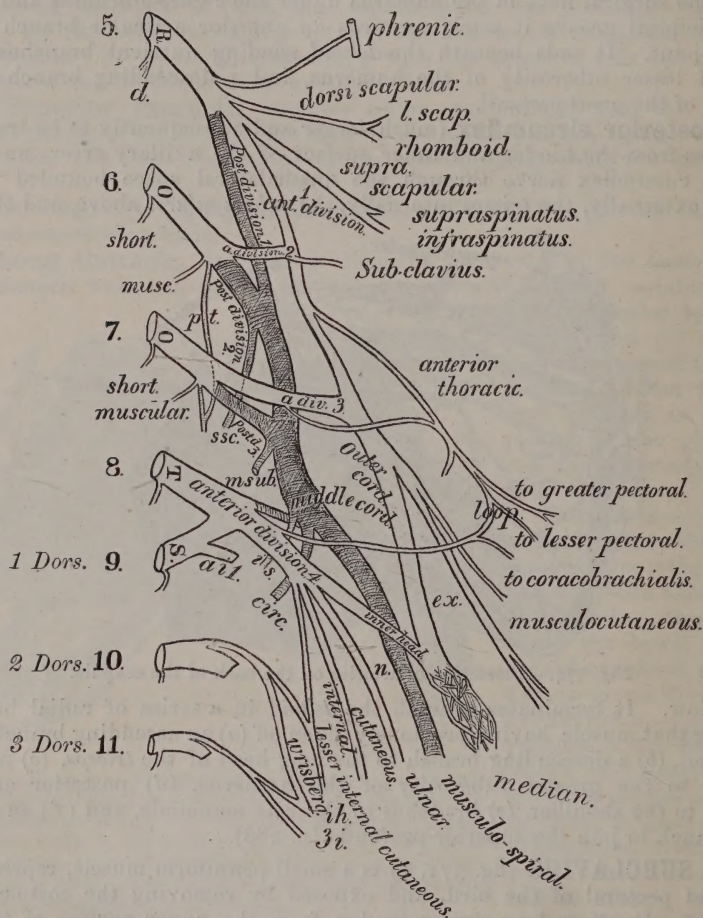


Fig. 375.—Diagram of brachial plexus.

trunk forms the **inner cord**, and the posterior divisions of the uppermost and middle trunks unite to form the **posterior cord**, which is joined, usually a little below the point where it begins to branch, by the small posterior division of the lowest trunk.

The branches which arise from the plexus in the neck and axilla are—

1. **Dorsi-scapular nerve.**—This arises from the fifth cervical and pierces the *scalenus medius*, passing under the *levator anguli scapulae*, to which it sends a branch, terminating in the *rhomboid* muscle (p. 252).

2. The **subclavian nerve** arises from the fifth close to its junction with the sixth, and descends inwards over the *scalenus anticus* and subclavian vein, and behind the clavicle. It often sends a branch inwards to join the phrenic nerve (§ 412), and enters its muscle by piercing the underlying fascia.

3. The **suprascapular nerve** arises from the upper trunk, but is chiefly derived from the fifth. It descends beneath the *trapezius* and clavicle, under the suprascapular vessels to the upper suprascapular ligament, under which it enters the supraspinous fossa. Here it divides into (a) branches for the *supraspinatus*, (b) minute articular branches to the hinder surface of the capsule, and (c) a terminal branch to the *infraspinatus* which passes beneath the spino-glenoid ligament to its destination. These branches accompany the divisions of the suprascapular artery.

4. **Posterior thoracic nerve**, or external respiratory nerve of Bell, arises by three roots, one from the fifth along with the rhomboid nerve, joined, as it emerges from the *middle scalenus*, by a twig from the sixth, and lower down, though not constantly, by one from the seventh. It descends vertically behind the axillary artery upon the outer surface of the *serratus magnus*, to which it is distributed, its course being parallel to the posterior axillary line. The filaments from the fifth supply the upper part of the muscle; from the fifth and sixth, the middle part; while those of the sixth and seventh supply the lower part (fig. 371, 28).

5. **External anterior thoracic nerve** arises by one filament from the anterior division of the upper trunk, and by two from the anterior divisions of the middle and inferior trunks. It gives off a large communicating branch to the next, and pierces the thin part of the costo-coracoid membrane with the pectoral branch of the thoraco-acromial artery to supply the clavicular and upper sterno-costal fibres of the *great pectoral*.

6. **Internal anterior thoracic nerve** (8 c.) passes between the axillary artery and vein, joins the communicating branch of the last, passes under the *lesser pectoral* which it supplies, and sends filaments to the deep sterno-costal part of the *great pectoral*.

7. **Circumflex nerve**, a large cord, arises from the posterior division of the uppermost trunk and sinks with the posterior circumflex artery through

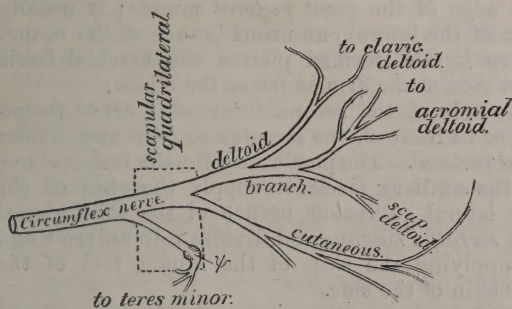


Fig. 376.—Diagram of the distribution of the circumflex nerve.

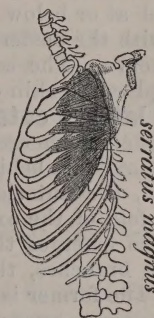


Fig. 377.—Serratus magnus, showing its tripartition.

the quadrilateral space, in which it divides into three branches: (a) one to the *teres minor*, dilated shortly after its origin into a pseudo-ganglion (fig. 376, Ψ), a reddish thickening of the perineurium; (b) a cutaneous branch which emerges about the middle of the hinder edge of the *deltoid* and supplies the skin over that muscle; (c) a large and often divided branch to supply the *deltoid* muscle. Two small branches supply respectively the front and the inferior parts of the

capsule, another is distributed to the greater tuberosity of the humerus and the wall of the bicipital groove.

8. **Upper subscapular nerve**, very short, arises from the posterior division of the uppermost trunk, some distance above the last, and divides into branches in the upper and middle parts of the *subscapularis* with the upper subscapular artery.

9. **Middle subscapular** arises from the united posterior divisions of the upper and middle trunks, below the last but above the circumflex. It descends close to the *subscapularis*, the lower third of which it supplies, and, passing downwards, ends in the *teres major* muscle.

10. The **long subscapular**, from the posterior division of the middle and lower trunks, sometimes appears to arise above the last, and descends, crossing the subscapular artery to end in the *latissimus dorsi* (fig. 371, 27).

165. The TERMINAL BRANCHES are :—

A. From the outer cord—

11. The NERVE TO THE CORACO-BRACHIALIS (7 c.), sometimes a branch of the following.
12. The MUSCULO-CUTANEOUS (p. 280, 5-6 c.).
13. The outer head of the MEDIAN (6-7 c.).

B. From the inner cord—

14. The inner head of the MEDIAN (p. 305, 8 c. and 1 d.).
15. The ULNAR (p. 307, 8 c. and 1 d.).
16. The INTERNAL CUTANEOUS (p. 280, 8 c. and 1 d.).
17. The LESSER INTERNAL CUTANEOUS (1 d.).

C. From the posterior cord—

18. The MUSCULO-SPIRAL (6-7-8 c. and 1 d., pp. 281, 298).

The nerve to the coraco-brachialis enters its muscle at the upper fourth of its inner side.

The two heads of the median unite external to the axillary artery which the inner head crosses, and the nerve thus formed descends along the outer side of the artery.

Its component nerve bundles are arranged in a plexiform manner, as can be seen when the nerve is teased out (see fig. 375).

The lesser internal cutaneous nerve lies internal to the axillary vein, and at or below the lower edge of the *great pectoral* muscle; it usually unites with the posterior division of the lateral cutaneous branch of the second dorsal nerve. The compound trunk thus formed pierces the brachial fascia and supplies the skin of the inner side of the arm as far as the elbow.

The lateral cutaneous branch of the second intercostal nerve (intercosto-humeral) emerges through, or in front of, the *serratus magnus* and divides into two branches behind the *great pectoral*. The posterior joins the last as above described, the anterior pierces the axillary fascia to supply the skin of the anterior fold of the axilla. The lateral cutaneous branch of the third dorsal nerve also emerges through the *serratus magnus* and divides into anterior and posterior branches, the latter supplying the skin of the hinder fold of the axilla. The former is lost in the skin of the side.

166. SERRATUS MAGNUS (fig. 377).—The flat muscle which forms the inner wall of the axilla arises by fleshy tongues from the nine upper ribs. The upper four origins are under the *great pectoral* (fig. 371, 8), the lower four indigitate with the *external oblique* (*ib.*, 9). The fibres converge to the vertebral edge of the scapula, into the whole length of which they are inserted.

The muscle is divisible into three parts. The slip from the first rib is joined to the foremost origin from the second by a tendinous arch, and the quadrate portion thus formed is inserted into the area for the *serratus* at the upper angle of the scapula (fig. 220, *Sup.*). The hinder slip from the second and that from the third rib make the weak triangular middle portion with diverging fibres inserted into the tendinous sling, which is imperfectly attached to the vertebral

edge of the scapula. The strong lower triangular part has its base at the fourth to the ninth ribs, and its apex at its insertion into the inferior angle of the scapula (fig. 220, *Inf.*). The fascicle lengths of the three parts are respectively 9, 12, and 15.

The *serratus magnus* lies on the ribs, *intercostal* muscles and a plane of connective tissue; it is covered by the parts in the axilla, and the lateral integument. It is supplied by the posterior thoracic nerve, and nourished by the superior thoracic, posterior scapular, and thoracico-dorsal arteries. It draws forward the scapula, especially its lower part, rotating it around a central axis. Or, the scapula being fixed, it can act as a muscle of inspiration.

Serratus magnus is essentially a muscle of the upper ribs which has become extended downward, coincidently with the tailward displacement of the scapula in higher vertebrates. The upper part is the primary portion.

Dissection.—Divide the *serratus* 2 cm. from the scapula, and cut the axillary artery and brachial plexus on the level of the clavicle and remove the arm from the body.

167. SURFACE-MARKINGS ON THE UPPER LIMB.—The most important points of superficial topography on the detached limb besides those already noticed (p. 262), are (1) the rounded prominence of the *deltoid*, (2) the sub-cylindrical swelling of the *biceps* on the front of the arm, (3) the inner and outer epicondyles of the humerus and the olecranon at the elbow. These lie in the same transverse line on the extended arm, but in flexion the lines joining these points form a triangle whose apex is downwards at the olecranon.

(4) The extensor muscles covering the outer epicondyle make a prominence at the outside of the elbow, while the flexors form a thicker but less projecting mass below the inner epicondyle. Between these and the bicipital swelling are the **outer and inner bicipital sulci**, which converge to the **antecubital fossa** in front of the elbow into which the *biceps* tendon sinks.

(5) The ulna is superficial along the postaxial edge of the forearm; the radius can be felt preaxially for its lower half. The positions of the two styloid processes should be noticed in pronation and supination. (6) Below and in front of the radial styloid process is the tubercle of the scaphoid, above the ball of the thumb or **thenar eminence**. Below and in front of the ulnar styloid is the pisiform bone above the ball of the little finger or **hypothenar eminence**. These eminences consist respectively of the short muscles of these two digits.

(7) A line from the middle of the clavicle to the middle of the antecubital fossa marks approximately the course of the axillary and brachial arteries. Lines from the latter point to the scaphoid and pisiform respectively, nearly correspond to the lines of the radial and ulnar arteries, the former of which can be felt pulsating during life for the lower half of the forearm. (8) The three rows of knuckles in the flexed hand consist respectively of the distal ends of the metacarpals, of the proximal and of the medial phalanges.

In the extended supinated arm the axes of arm and forearm make with each other an angle, salient inwards of 165° in the female, and 172° in the male.

Skin.—On the front and inner side of the arm and forearm the skin is looser, thin, allowing the veins to shine through, and more sensitive, with fewer and smaller hairs and more numerous sweat glands. That over the biceps is so fine in texture that it was selected by Tagliacozzi as the most suitable for rhinoplastic operations. On the back and outside it is thicker, more adherent, less sensitive, with longer hairs, thirteen to the sq. cm., and about 140 sweat glands in the same area. Over the olecranon the skin is loose and transversely wrinkled in the extended arm, and the cuticle is thick and rough. The skin is also loose on the back of the first interphalangeal joint, and transversely wrinkled though not loose on the other knuckles. The skin in front of the wrist is marked by transverse lines (**rasceta**) where it

is tied to the underlying fascia. In the palm the skin is similarly tied down by fibrous bands along depressed lines, which are the lines of flexion. The intervals between these are prominent areas in which the spaces between the lines of adhesion are filled by granular fat.

The line limiting the thenar eminence (*linea vitalis*) corresponds to the marginal attachment of the palmar fascia. The *linea cephalica* starts below this on the level of the first metacarpo-phalangeal joint, and slopes upwards to the middle of the fifth metacarpal. The *linea mensalis* or line of metacarpo-phalangeal flexion is lower on the extended hand, about 1 cm. above the line of the joints, and from it *valleculæ* pass to each finger corresponding to the lines of attachment of the skin to the sheaths of the flexor tendons. Between these are the interdigital hillocks named from thumb to little finger, *eminentie Veneris, Jovis, Saturni, Solis, Mercurii*. The vertical line from the rasceta to the vallecula of the middle finger is the *linea hepatica*. These lines vary with the relative lengths of the metacarpals and the amount and disposition of the fibres of the palmar fascia and fat. They are present in the foetus of the sixth month.

The palmar epidermis is usually about .8 mm. thick in males, but varies with occupation. It has neither hairs nor sebaceous glands, but possesses

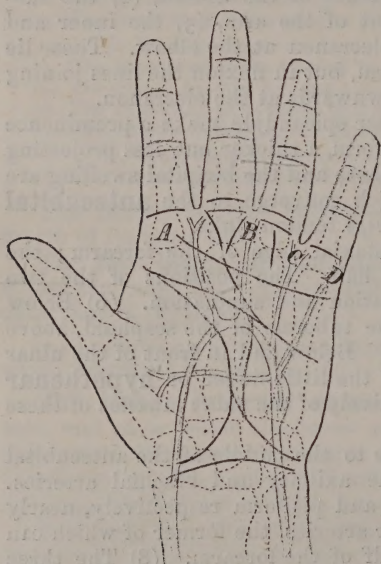


Fig. 378.—Front of hand, showing cutaneous folds and their relations to the vessels and the bones; the latter shown by dotted lines.



Fig. 379.—Back of hand, showing nails, skin folds, and areas of nerve distribution (see §§ 185, 190).

about 320 sweat glands in each sq. cm. The dermal papillæ are numerous, large and often compound, containing touch corpuscles. On the soft rounded pulps of the last joints of the fingers these are arranged in irregular concentric ridges, whose pattern varies in each different hand. On the palmar side of the interval between each pair of fingers is a sharp fold, the **plica interdigitalis**. Crossing the palmar side of each finger at its base are transverse flexion folds, placed about 1.7 cm. below the metacarpo-phalangeal joint. These are single for the index and little fingers, double for the two others. Similar flexion folds mark the skin on the palmar surfaces of the other finger joints, whereof the second is always double, the third generally single. These folds are in the male on an average 2.6 mm. above the respective joints, in the female 1.5 mm.

On the back of the first phalanx is an oval patch of skin bearing hair follicles, on the last is the nail.

168. THE NAIL is a flattened mass of superposed lamellæ of horny epidermal cells (fig. 380, *a*) representing an enormously developed *stratum lucidum* (p. 93), over the base of which is a soft fold, the partially developed *stratum corneum* or **eponychium** (*ib.*, *f*). Its proximal margin is sunk under a fold of skin, the **nail-fold**; its borders are overlapped by similar folds, the **nail-walls** (*ib.*, *g*), but its distal end is free. The nail rests on a vascular and sensitive **nail-bed** of corium (*ib.*, *d*), the upper lenticular portion of which is the **matrix**, whose papillæ are arranged in long ridges, and from which the nail grows. This matrix is extremely vascular, and its arteries appear to communicate here and there directly with the veins. The part of the nail which lies on the matrix is the **root**, and it appears white and opaque; it projects below the nail-fold in the thumb as the **lunula**, but is usually covered by it in the other fingers. The root differs from the rest of the nail in possessing a *stratum spinosum* of cells with closely set prickles, as well as some layers of granular cells between these and the *stratum lucidum*, containing a substance differing from eleidin. The nail-bed below the matrix is also longitudinally ridged.

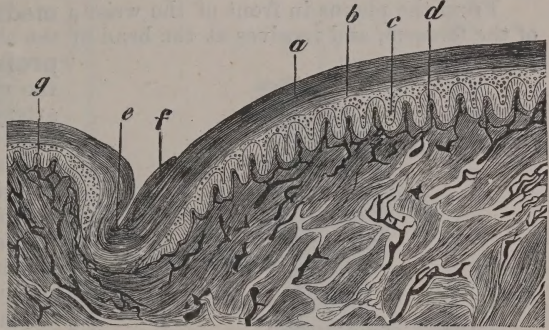


Fig. 380.—Horizontal section through half the nail magnified.

Development.—Each nail first appears in the third month as a solid mass of cells of the stratum lucidum growing downwards in the nail-fold under the stratum corneum. They burst through this in the sixth month, and in the seventh begin to have a free lower edge. A nail grows from the fold to the free border in from one to eight months, rapidly in youth, slower in old age. That of the ring finger usually grows the quickest.

The growth of the nail sympathises with the condition of health; during acute diseases it is checked, and a transverse furrow forms on the nail, due to this stoppage of growth. In scrofulous and phthisical persons the nails are incurved and clubbed. This condition characterises the *hippocratic hand*.

Dissection.—Divide the skin by a vertical median incision along the front of the arm down to the front of the wrist, where it is to be divided transversely. Reflect the two flaps of skin laterally. The superficial fascia usually contains much fat except over prominent points. There is a *bursa* over the olecranon, and a second is occasionally present over the inner epicondyle, and one over the ulnar styloid process. Expose the superficial veins and nerves.

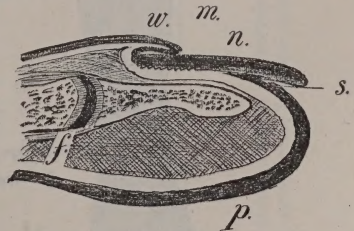


Fig. 381.—Vertical section through ungual phalanx of little finger, $\times 2$ —*w*, root; *m*, matrix; *p*, pulp of finger; *s*, nail-bed.

169. THE SUPERFICIAL VEINS of the hand form three more or less united plexuses which lie respectively (*a*) on the back of the radial side of the hand, (*b*) on the back of the ulnar side, and (*c*) on the front of the wrist. The circulation in the fingers is peculiar in that the arteries are deep and palmar while the veins are superficial and dorsal, forming arches on the backs of the first phalanges; these end in the two dorsal plexuses which, therefore, receive most of the blood returning from the fingers. The internal dorsal plexus

is formed by the union of a vein from the little finger (**v. salvatella**), with veins from the third and fourth interdigital cleft. The external by the junction of one from the thumb (**v. cephalica pollicis**), with veins from the index and middle fingers. From the internal dorsal plexus two veins ascend, a small **anterior superficial ulnar**, and a larger **posterior superficial ulnar**. These unite above the elbow, and form the **basilic vein** which ascends in the inner bicipital sulcus to the middle of the arm, where it pierces the brachial fascia and joins the inner *vena comes* of the brachial artery to form the axillary vein.

From the plexus in front of the wrist a **median vein** ascends on the front of the forearm, and receives at the bend of the elbow a deep branch (**mediana**

profunda), formed by the union of the outer *vena comes* of the ulnar artery with muscular and radial recurrent veins. Above this the median divides into two branches—(1) **median basilic**, larger and more horizontal, running upward and inwards over the bicipital fascia, which separates it from the brachial artery, uniting above either with the anterior ulnar or the basilic vein.

This is the vein from which it is most easy to bleed, and hence its relative anatomy should be closely observed.

(2) The **median cephalic**, smaller, external and more vertical, ascends over the external cutaneous nerve and joins the next in the external bicipital sulcus.

The **superficial radial vein** ascends from the radial dorsal plexus of the hand, along the outer side of the forearm, and unites with the last, forming the **cephalic vein** which passes along the outer edge of the *biceps*, between it and the *deltoid*, and then between the *deltoid* and the *great pectoral*, finally dipping through the costo-coracoid membrane below the clavicle to cross the axillary artery and end in the axillary vein (§ 160).

These veins are variable in relative size and arrangement. The basilic is the stem

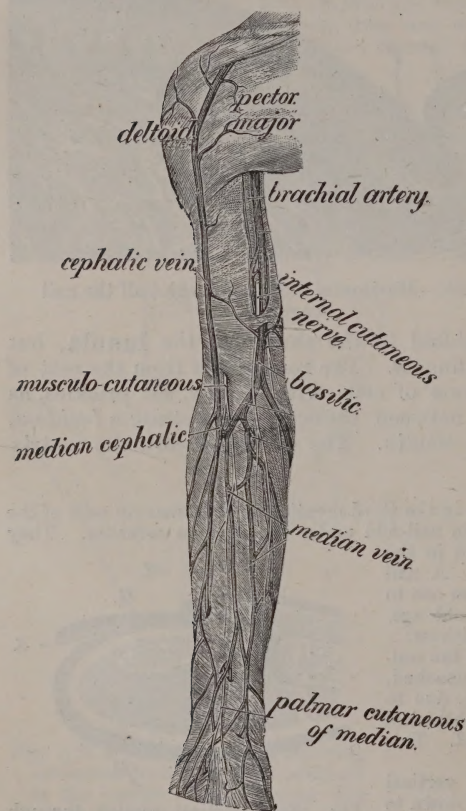


Fig. 382.—Superficial veins and nerves of the front of the forearm—commonest arrangement.

towards which all at first converged, and the radial originally crossed from without at the elbow to join it, receiving in its course the median and a descending branch from the outer bicipital sulcus. The adult form of the cephalic vein is a secondary development due to the dilatation of a communication between the uppermost radicle of this descending vein, and one of the thoracico-humeral veins. Intermediate forms are common. There are usually 3 valves in the basilic, 4 in the cephalic, 6 in the radial plexus and radial vein, 8 in the ulnar plexus and ulnar veins, 7 in the median plexus. These, however, are very variable, and better marked in the young. They usually become much fewer in the arm of the labourer. There are no superficial veins on the extension side of the elbow.

170. CUTANEOUS NERVES OF THE ARM AND FOREARM.—The skin over the upper half of the *deltoid* is supplied by the outer supraclavicular

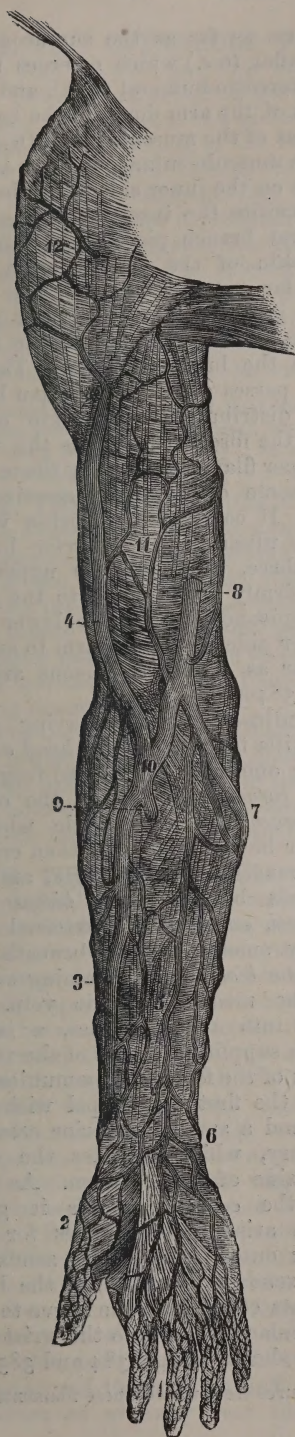


Fig. 383.—Primitive arrangement of the forearm veins in which the cephalic vein (4) descends to join the radial vein (3) and to empty its blood by (10) the median basilic into (8) the basilic vein. The digital palmar veins are represented disproportionately large.

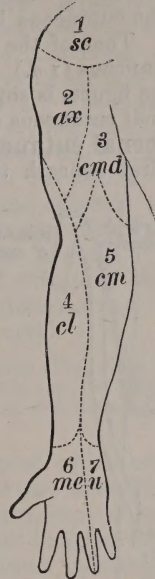


Fig. 384.—Diagram of the areas of distribution of the cutaneous nerves on the front of the upper limb.

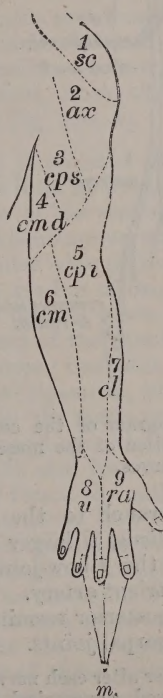


Fig. 385.—Diagram of the areas of distribution of the cutaneous nerves on the back of the upper limb—cmd, lesser internal cutaneous.

nerve* (4 c.), that of the outer side of the arm as far as the supracondyloid region by the cutaneous branch of the circumflex (6 c.) which emerges behind the *deltoid*. That of the inner side by the intercosto-humeral (2 d.), and lesser internal cutaneous (1 d.) The skin of the rest of the arm down to the hand, as shown in the figure, is supplied by the branches of the musculo-spiral (6, 7, 8 c.) of the internal cutaneous (8 c. 1 d.), and of the musculo-cutaneous (5-6 c.)

The **internal cutaneous nerve** descends on the inner side of the brachial artery, at first beneath the deep fascia. Opposite the insertion of the *great pectoral* its first branch pierces the fascia to end in the skin of the arm wherein it is traceable as far as the elbow. The main trunk divides into two branches as it passes along with the basilic vein through the *hiatus semilunaris* in the brachial fascia. The *anterior* branch passes *under* the median basilic vein, and is distributed to the skin of the inner half of the forearm as far as the wrist, some of its upper filaments crossing the median basilic vein, some of its lower crossing the median vein. It communicates below with a branch of the ulnar. The *posterior* branch divides into three, of which the uppermost crosses and is firmly bound down to the front of the inner epicondyle; the two lower pass round the inner side of the forearm to supply the skin as far as the subcutaneous area of the ulna (figs. 384 and 385, cm).

The **musculo-cutaneous** having separated in the axilla from the outer head of the median on the one side, and (often) from the nerve to the *coraco-brachialis* on the other, pierces the *coraco-brachialis* muscle wherein it will hereafter be dissected. It then crosses between that muscle and the *biceps*, and descends outwards between the *biceps* and *brachialis anticus*, entering the external bicipital sulcus by emerging from beneath the outer edge of the *biceps*, and becoming superficial under the median cephalic vein. It finally divides into two branches, a larger posterior, which supplies the skin of the radial side of the back of the forearm, communicating at the base of the first metacarpal with the radial nerve; and a smaller anterior crossing the radial artery, which supplies the skin of the radial side of the forearm. As this nerve leaves the *coraco-brachialis* it gives

off a large branch to the *biceps*, below which arise two branches for the *brachialis anticus*, a larger inner and a smaller outer. The latter sends off filaments to the elbow-joint, while the former sends a branch into the bone with the nutrient artery. No articular filaments come from the nerve to the *biceps*. The posterior terminal branch sends articular filaments to the wrist and the preaxial carpal joints. Its cutaneous area is shown in figs. 384 and 385, cl.

* The number after each nerve refers to the spinal source from which these filaments are ultimately derived, c = cervical, &c.

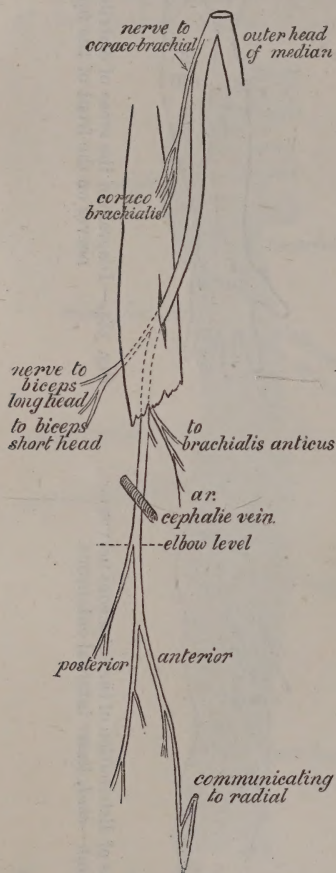


Fig. 386.—Diagram of the course and distribution of the musculo-cutaneous nerves.

171. THE CUTANEOUS FILAMENTS OF THE MUSCULO-SPIRAL (§§ 165, 186) are two, posterior internal or superior, and posterior external (fig. 405). The internal arises in the axilla on the level of the lower edge of the *latissimus dorsi* tendon, and pierces the fascia to supply the strip of skin behind the area of distribution of the intercosto-humeral nerve. The external, which arises while the nerve is in the musculo-spiral groove, divides into two branches which may arise independently and which always pierce the fascia separately. The superior becomes superficial below the insertion of the *deltoid*, close to the cephalic vein, and supplies the skin of the arm over, and external to, that vein as far as the elbow. The inferior is larger and appears superficially close to the outer intermuscular septum. It sends a transverse branch outwards and backwards, and descends to supply a narrow strip of skin over the superficial aspect of the ulna between the areas of the internal cutaneous and the musculo-cutaneous nerves as far as the wrist (fig. 385, *cps* and *cpi*).

It should be borne in mind that there is no hard line between these distribution areas of cutaneous nerves, but around each tract there is an area of skin supplied conjointly by the two or more contiguous nerves. In other words, the areas of distribution of the several nerves overlap each other.

172. THE LYMPHATICS of the arm, the largest of which are superficial, arise in close-meshed plexuses on the back of the hand and ascend in three sets. The largest set of these converge to the ulnar side of the forearm and ascend in front of the posterior ulnar vein as far as the inner bicipital sulcus, where they pass into a small gland placed 4 cm. above the inner epicondyle and close to the basilic vein. Into this gland also the second set or palmar superficial lymphatics pass, which have ascended on the ulnar side of the forearm internal to the median vein. The lymphatics from the radial side unite with these crossing inwards obliquely.

From the gland three trunks ascend, pierce the hiatus semilunaris, and end in the lowest of the pectoral glands in the axilla. The third set of lymphatics are deep and accompany the deep vessels; they usually end in a small deep gland between the *pronator teres* and *brachialis anticus*, from which a large lymphatic ascends with the inner brachial vena comes (fig. 370, *h*).

173. THE DEEP FASCIA of the arm (fig. 383) is exposed by removing the superficial fascia and its veins and nerves from the limb as far as the elbow. The deep fascia begins above, along the vertebral edge of the scapula, over the *infraspinatus*, where it is strengthened by arching fibres continuous with the edge of the *trapezius*. It splits into two layers at the hinder edge of the *deltoid*, a stronger superficial lamina which is adherent to the tendon of origin of that muscle, between whose fascicles it sends sheaths, and a deeper, weaker layer continued under the *deltoid* on the *infraspinatus* to the front of the shoulder, where it forms the superficial wall of the great subacromial bursa; over this it becomes continuous with the anterior edge of the coraco-acromial ligament, whose hinder border is continuous through weak areolar tissue with the fascia covering the *supraspinatus* muscle. Downward, this fascia is continued over the front of the shoulder-joint, as the **semi-vagina humeri** (fig. 388), and its backward prolongation beneath the coracoid over the *subscapularis* forms the **subscapular fascia**. Beneath the *great pectoral* muscle it is continuous into the outmost part of the costo-coracoid membrane, as it descends from sheathing the *lesser pectoral*, and along the lower border of the *pectoral* the deep and superficial layers of the fascia unite in the **axillary fascia**. It receives an accession of fibres from the *great pectoral* and *deltoid*, and descends on the arm as a close envelope for its muscles, sending to each intermuscular ridge of the humerus a strong double-layered **intermuscular septum**. The outer of these is strong above, and forms an archway over the musculo-spiral groove, through which pass

the nerve of that name and the superior profunda artery. This septum is continued upwards between, and is inseparable from, the origin of the *brachialis* and *triceps*, and its upper fibres, interrupted by the deltoid, form the external **frænum suspensorium**, attached to the *great pectoral* tendon (§ 158).

The **external intermuscular septum** divides below into two weak prolongations, the more distinct of which separates the *long supinator* from the *triceps*, the weaker separates it from the *brachialis*, and is lost below.

The **internal intermuscular septum** is strongest above the inner epicondyle, becoming weak near the *coraco-brachialis* to whose tendon it is attached, and from which it is prolonged upwards as a fibrous arch over the

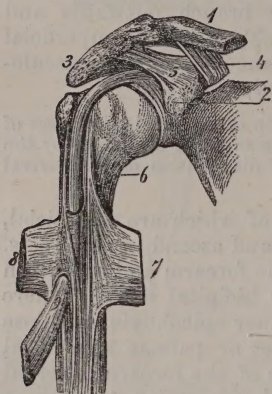


Fig. 387.—The bicipital groove and the fascial relations of the tendons that border it—7, *teres major*; 8, *great pectoral*.

tendon of the *teres major*. Some fibres of it are prolonged upwards to the lesser tuberosity and shoulder capsule as a **frænum suspensorium internum**. This septum is pierced by the ulnar nerve, the inferior profunda and anastomotic arteries, and passes behind the *pronator teres*. In front of this septum in the middle of the arm there is an oval opening in the deep fascia (**hiatus semilunaris**) for the basilic vein and its accompanying nerves and lymphatics. The fascia sends an areolar septum between the *biceps* and *brachialis* which sheathes the brachial artery and binds it to the surface of the latter below.

A strong fibrous band in front of this septum sometimes arches over the median nerve and gives origin by its deep surface to the upper slip of the *pronator teres*. When the humeral attachment of this is ossified it forms the **supracondylloid process**.

As the fascia descends in front of the elbow, it is strengthened by a strong expansion derived from the *biceps* tendon which stretches downwards and inwards over the muscles which arise from the inner epicondyle to be lost in the fascia of the forearm. Its upper border is sharp and crescentic, crossed by the basilic vein. Its lower border is defined by the hole for the deep median vein. This expansion is named the **semilunar or bicipital fascia**. The median basilic vein and the internal cutaneous nerve overlie this fascia, the brachial artery underlies it. Throughout the arm the fascia consists of a superficial layer of circular fibres, and a deeper of longitudinal.

Dissection.—Remove the fascia from the surface of the *infraspinatus* and *deltoid* muscles.

174. DELTOID (figs. 353, 368), triangular and coarsely fasciculated, arises from the lower and outer edges of the outer two-thirds of the scapular spine, of the acromion, and of the outer third of the clavicle; it is inserted into the deltoid tuberosity of the humerus.

Its origin from the spine begins at the tuberculum spinæ and consists of fleshy and short tendinous fibres between the enclosing layers of fascia. The clavicular origin is mostly fleshy. The acromial portion consists of eleven fascicles. From the four marginal tubercles of the acromion there arise as many tendons which are united by a thin aponeurosis covered on each surface by fleshy fibres. The insertion is by four planes of tendons which converge below and are attached to the four ridges of the deltoid tuberosity of the humerus. To the sides of each tendon of origin and insertion muscular fascicles are attached in a bipenniform manner, and the fleshy fibres from the apex of each tendon of origin are inserted fleshily into the humerus between the tendons of insertion and *vice versâ*. By this arrangement the number of fibres per sq. cm. of cross-section is increased threefold, and the fibres are of the proper functional length. The three parts of the *deltoid* can act separately in raising the arm in different directions. The scapular part can only raise it through an angle of 45°, the acromial and the clavicular through 90°.

The anterior border is contiguous to, and below confluent with, the *great pectoral*. The cephalic vein and humero-thoracic artery lying superficially in the groove between them (Mohrenheimer's space).

The *deltoid* is supplied by the circumflex nerve (5 and 6 c.) which enters its under surface posteriorly, the nerve dividing into three branches before entering the muscle. It is nourished by branches of the posterior circumflex and thoracico-humeral arteries and by the rete acromiale.

Dissection.—Detach the *deltoid* from its insertion and reflect it. Two large bursæ underlie the muscle, one between its deep surface and the greater tuberosity of the humerus; the second extends under the acromion. These frequently communicate with each other, and occasionally with the shoulder. The *deltoid* covers the *infraspinatus* and *teres minor*, the circumflex vessels and nerves, the coracoid process and the muscles attached thereto, the coraco-acromial and capsular ligaments and the outer portion of the humerus below the great tuberosity (fig. 388). Remove the deep portion of the infraspinous fascia.

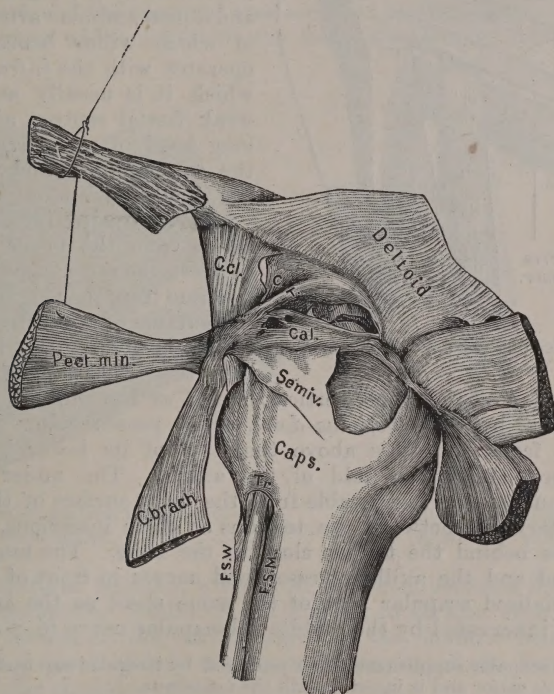


Fig. 388.—Parts covered by the clavicular portion of the deltoid—Cal., coraco-acromial ligament; C.cl., coraco-clavicular membrane; F.S.W., attachment of the frænum suspensorium from the latissimus dorsi (Winslow's); F.S.M., frænum suspensorium of the pectoral (M'Dowel's).

175. SCAPULAR MUSCLES.—*Infraspinatus* (fig. 389), triangular and superficially tripartite, fills most of the infraspinous fossa. Its upper part arises from the lower surface of the scapular spine, and, descending outwards, overlaps the middle portion which arises from the posterior half of the infraspinous fossa. The lowest part springs from the hinder surface of the oblique infraspinous line (p. 135). The middle fibres converge to a tendon which begins about the middle of the fossa, and into which the upper and lower portions are also inserted. The tendon crosses and often adheres to the capsule of the shoulder, though sometimes a bursa intervenes. It is inserted into the middle facet of

the great tuberosity of the humerus, which it can rotate outwards. The infraspinous artery and nerve (5 c.) enter its deep surface.

Teres Minor (fig. 389).—A small deep muscle, originally a dismemberment of the deltoid, arises by a pointed fleshy origin between two tendinous planes from the upper area between the oblique infraspinous line and the posterior axillary lip of the scapula as far as the infraglenoid tubercle. It is inserted

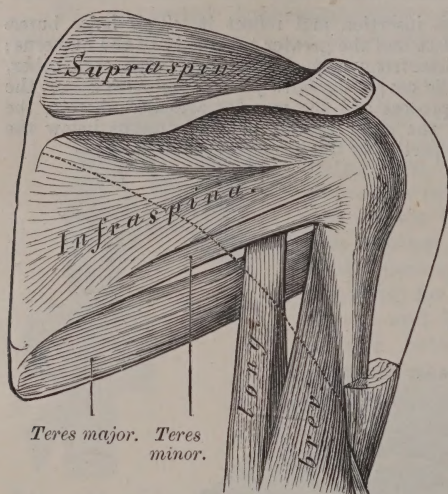


Fig. 389.—Muscles of the back of the scapula.

by a tendon into the lowest facet of the greater tuberosity of the humerus, and by very short tendinous and fleshy fibres into the bone beneath that process. It is supplied medially and in front by the pseudo-gangliated branch of the circumflex nerve (5 c.), and is nourished by the posterior circumflex and dorsal scapular arteries, the latter of which winds beneath it. It cooperates with the *infraspinatus*, from which it is usually separated by a weak fascial septum, and lies on the long head of the *triceps*, the edge of the *subscapularis*, and the capsule of the shoulder-joint.

Teres major (figs. 389; 390, 10) arises from the lower area included between the same scapular lines as the last, and from the neighbouring part of the surface of the infraspinous fascia which it overlaps. It is inserted into the inner lip of the bicipital groove by a tendon of the same vertical height as the muscle. Its origin is overlapped behind by the *latissimus dorsi*, which passes below it, and whose tendon lies in front and rises above the level of its lower border. These two muscles form the hinder fold of the axilla. The under edge of the *latissimus* tendon becomes inseparable from the front surface of the *teres major*, but a bursa intervenes between the tendons at their insertions, and a second small bursa lies behind the tendon close to the bone. The long head of the *triceps* is behind and the axillary vessels and nerves in front of it. The *teres major* is a specialised scapular part of the same sheet as the *latissimus dorsi* (p. 251), and is innervated by the middle subscapular nerve (6–7 c.).

An inconstant scapular supplemental slip produced by irregular segmentation sometimes arises with the *teres major* and is inserted with the *latissimus*.

This muscle has a peculiar skew shape, and is thickest medially, owing to the different obliquities of its upper and lower fibres.

Between the *teres major* and *minor* there is a narrow slit, becoming triangular on dissection and divided by the long head of the *triceps* into two parts—(a) a triangle containing the subscapular vessels, and (b) a quadrilateral space containing the posterior circumflex vessels and nerve. These spaces have been already seen on their ventral surface, but there the *subscapularis* forms their upper boundary in place of the *teres minor*.

Dissection.—The coraco- and acromio-clavicular joints and the coraco-acromial ligaments should now be examined (p. 140), after which the clavicle is to be removed. Beneath the trapezius a considerable *supraspinous fatty pad* rounds off the angularity of outline of the scapular spine, but disappears by absorption in phthisis and disease of the shoulder-joint. Under it is the supraspinous fascia consisting chiefly of longitudinal fibres attached to the margin of the fossa, becoming very strong as it arches over the suprascapular notch where, being reinforced by special scapulo-coracoid fibres, it forms the superior ligament of the notch (p. 136). This fascia becomes weak as it approaches the shoulder, but, receiving supplemental fibres, it suddenly strengthens into the coraco-acromial ligament. Remove this fascia and ligament and expose the subjacent muscle.

Supraspinatus (fig. 389) fills and bulges above its fossa, from the inner half of which it arises, as well as from nearly the whole length of the upper border of the scapula and the scapular spine, and from the deep surface of its investing fascia. Its fibres converge to a tendon which passes under the coraco-acromial ligament, beneath the subacromial bursa, and is inserted into the uppermost facet of the greater tuberosity. It crosses the supraspinous vessels and nerve (5 c.) which supply it and the capsular ligament to which it is adherent. It co-operates with the *acromial deltoid* in raising the arm.

Dissection.—The dorsal scapular and suprascapular vessels and nerves should next be traced (p. 270) by dividing the supra- and infraspinous muscles. Draw the axillary vessels and nerves outwards and remove the subscapular fascia, dissecting it from the shoulder towards the vertebral edge of the scapula.

Subscapularis.—A compound penniform muscle filling the fossa of that name and arising from its floor, with the exception of the smooth part close to the scapular neck and the marginal area occupied by the *serratus magnus*. From each of the ridges which subdivide the fossa, a tendinous plane arises, giving

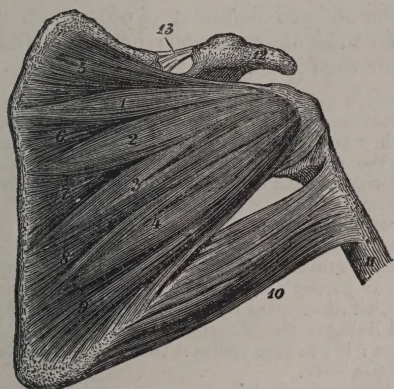


Fig. 390.—Subscapularis muscle and teres major.

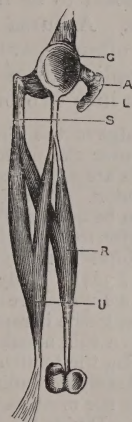


Fig. 391.—Biceps dissected to show its separate constituents.

origin to bipenniform fascicles, while from the sulci between them fleshy fibres arise which soon become tendinous. There are in all nine such fascicles which converge to a tendon on the ventral aspect of the shoulder below the coracoid process. This is inserted into the lesser tuberosity of the humerus and into the capsule of the shoulder-joint.

A constant, but not always separate fascicle arises from the groove between the axillary lips of the scapula, and, projecting below the margin of the bone, is inserted fleshily below the lesser tuberosity. The subscapularis is a portion of the same sheet as the latissimus.

It is supplied by the short subscapular nerve (5 and 6 c.) above, and by the middle subscapular (6 c.) for its lowest four portions, and is nourished by the short subscapular and branches of the long subscapular arteries.

Its tendon underlies the short head of the *biceps* and the *coraco-brachialis*, from the deep surface of whose origin a fibrous band, the remains of the *coraco-brachialis brevis* muscle, often stretches to the top of the inner lip of the bicipital groove. A bursa occasionally intervenes to allow these muscles to glide over the *subscapularis* tendon. By its penniform arrangement its real cross-section is more than double its apparent, and its short fibres can rotate the humerus inwards with a quick stroke, depressing the arm when raised. A bursa develops beneath its tendon in the last month of foetal life, which very early communicates with the joint, so that on raising the tendon the capsule usually appears open. Some of its fibres arise from the investing fascia, which is adherent to its tendons of origin.

Dissection.—Remove these muscles and trace to their terminations the scapular vessels. The shoulder-joint should also be dissected now (p. 144), but the tendons of *biceps*, *coraco-brachialis*, and *triceps* must be left uninjured. Divide the brachial fascia along the middle of the *biceps* and reflect it from the surface of the muscle, sparing the bicipital fascia below.

176.—BICEPS arises by two heads which remain distinct for its upper half. The long head begins within the capsule of the shoulder as a flattened tendon arising from the supraglenoid tubercle and the glenoid ligament. Having arched over the head of the humerus it escapes from the capsule through the bicipital groove, underlying the *great pectoral* tendon, to the deep surface of which it is tied by its sheath (fig. 387, 9). Below the *pectoral* it becomes fleshy, and about the middle of the arm unites with the second or short head. This portion arises from the coracoid process by fleshy and tendinous fibres, along with the *coraco-brachialis*, separating from which, it becomes fleshy, and joins the long head in front of the *brachialis anticus* muscle. At the antecubital fossa the fleshy belly tapers suddenly to a tendon, from the front of which the bicipital fascia (§ 173) originates, and, having given this off, it sinks into the depth of the fossa to be inserted into the lower and hinder part of the tubercle of the radius. A bursa lies between it and the front of the tubercle, and a second bursa often separates it from the oblique ligament (§ 96) which crosses it. It is supplied by a branch of the musculo-cutaneous nerve (6 and 7 c.) which divides into two branches, one for each head.

The inner edge of the *biceps* is the surgeon's guide to the brachial artery, from which two branches enter the muscle. One of these is derived from the *vas aberrans* (p. 289). When the heads are separated downwards they are seen to end as a bipenniform muscle in the terminal tendon. Both heads arise from the coracoid element of the shoulder-girdle, and the insertion can be artificially divided into two planes, a superficial derived from the short head and a deeper from the long. Fibres from both enter the bicipital fascia which is the remains of a cubital flexor lying ulnawards of the muscles from the inner condyle (*cf.* the popliteal space, § 364). Early in the third month of fetal life the tendon of the long head of the *biceps* lies in a duplicature of the embryonic capsule and is extra-articular, but by absorption of the underlying tissue it rapidly works its way through the ligament, the sheath of capsule being reduced to a thin membranous layer which disappears by the sixth month, except as a synovial fold tying the tendon to the synovial lining of the bicipital groove.

The *biceps* flexes and supinates the forearm: it can also protract the arm and make tense the fascia. It is the most variable muscle in the body.

Dissection.—Divide the *biceps* in the middle and reflect it.

177. BRACHIALIS ANTICUS (figs. 392, 393, 396) covers the front of the lower half of the humerus (from which it arises) and the humero-ulnar joint. Its origin stretches upwards by short processes, one on either side of the deltoid tuberosity; its inner border arises also from the inner intermuscular septum. The nearly parallel fascicles average 9 cm. long, are supplied through the musculo-cutaneous from the sixth cervical nerve and end in a flat tendon which begins superficially, and which, along the outer border, is reflected into the muscular substance. It is inserted chiefly by tendon into the tuberosity of the ulna, into a ridge leading to the inner tubercle of the coronoid process, and by a few inner fibres into the capsule of the elbow. On its surface lies the *biceps*, external to which it becomes superficial, internally it bears the brachial vessels, median and musculo-cutaneous nerves on its surface. It flexes the elbow.

The outer upper process of origin is largely tendinous, attached to the *deltoid* tendon, and to a small extent of the external intermuscular septum above the musculo-spiral groove; the inner, which is thin, and like the rest of the origin, fleshy, is peculiar to man and his allies. The thin part arising from the front of the outer supracondyloid area is overlapped internally by the rest of the muscle, externally by the *supinator longus*. In the groove between these muscles the musculo-spiral nerve descends, lying on those deeply placed fibres which converge to the reflected part of the tendon and supplying them with filaments (7 c.). The insertion is 2.5 cm. from the fulcrum, and in complete extension its resultant makes an angle of 25° with the axis of the ulna. Occasionally the musculo-cutaneous nerve, or a plane of areolar tissue, separates a portion of its head from the rest of the muscle, and this passes forwards to join the *biceps*, making for it a third or humeral head.

178. CORACO-BRACHIALIS (fig. 392) arises by a tendon from the coracoid process, and by fleshy fibres from the contiguous short head of the biceps. It is inserted into a line on the middle third of the humerus in front of the attachment of the inner intermuscular septum, and above the foramen

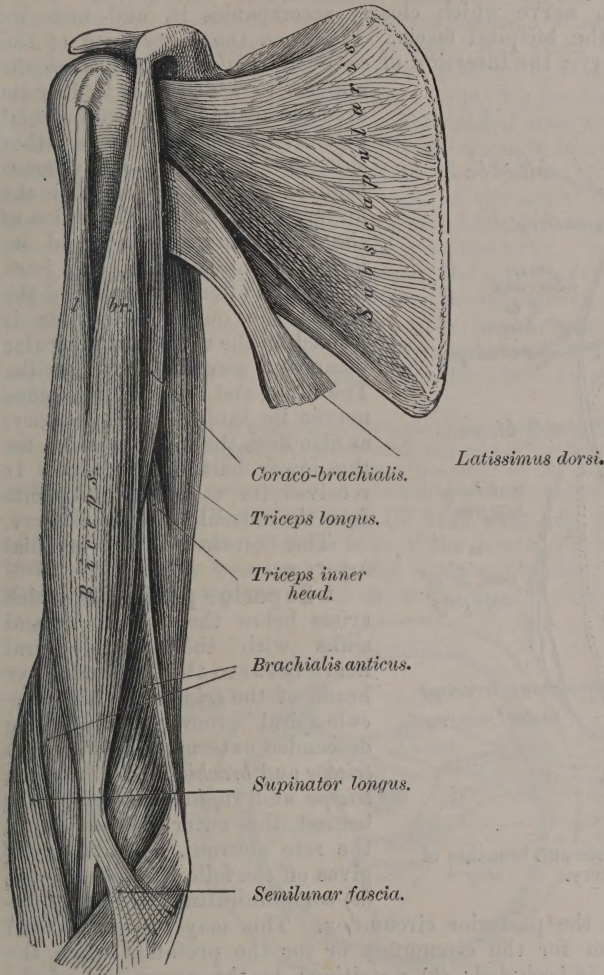


Fig. 392.—Muscles of the front of the arm.

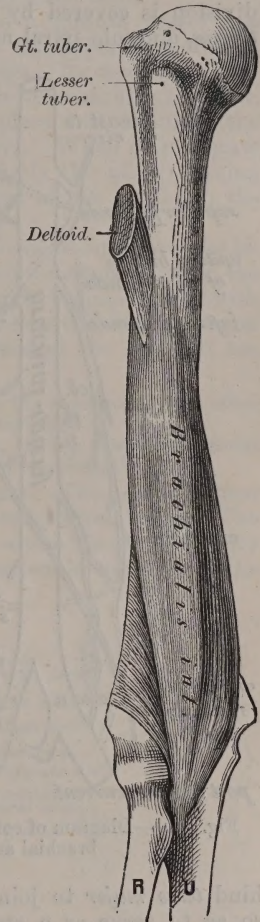


Fig. 393.—Brachialis anticus.

for the nutrient artery. It is covered above by the *pectoralis major*, and overlaps at first the axillary and brachial arteries, but the latter lies below upon its insertion. It has, behind it, the tendon of *subscapularis*, of *latissimus dorsi* and *teres major* and the inner head of the *triceps*. The tendon is attached to the inner intermuscular septum, an arch of which is continued upwards over the tendon of the *latissimus dorsi*.

The muscle is divided into two strata by the musculo-cutaneous nerve which pierces it, the superficial part being the larger and longer. It is nourished by a branch of the brachial artery, and supplied above by a branch from the outer cord of the brachial plexus (7 c.).

179. THE BRACHIAL ARTERY, the downward continuation of the axillary (§ 162), descends along the inner side of the *coraco-brachialis* and *biceps* which overlap it, to the antecubital fossa, ending by bifurcation opposite the head of the radius. It lies at first internal, then anterior to the shaft of the humerus, and is covered by skin and fascia, crossed in its middle from without inwards by the median nerve which closely accompanies it, and near its division is covered by the bicipital fascia. It lies on the inner head of the *triceps*, musculo-spiral nerve, the insertion of *coraco-brachialis*, and the *brachialis anticus*, to which it is tied by its areolar sheath. The two brachial veins (*venae comites*), one on either side, are joined by many cross branches—the inner, which is the larger, is formed by the union of the ulnar, interosseous, and inferior profunda veins, and joins the basilic after it has pierced the fascia; the outer or smaller is formed by the radial and muscular veins, and ascends to the axilla. The ulnar and internal cutaneous nerves lie internal to the artery, as also does the median nerve for the lower half of the arm. It receives its vasomotor filaments from the musculo-cutaneous nerve.

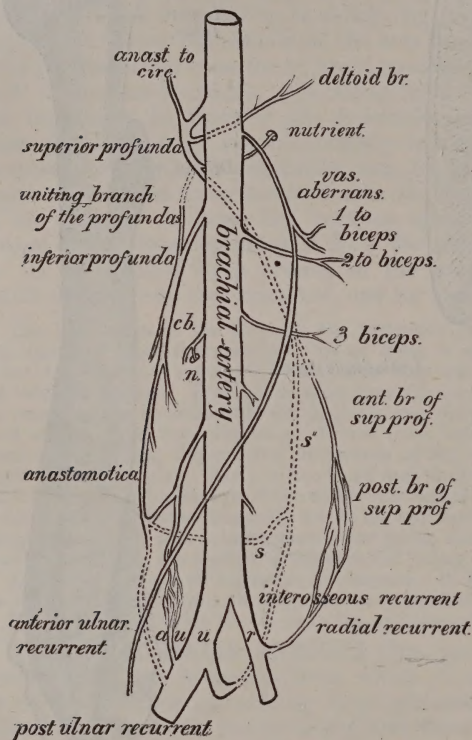


Fig. 394.—Diagram of course and branches of brachial artery.

behind *teres major* to join the posterior circumflex. This may become dilated so as to serve as a stem for the circumflex or for the profunda when the normal source of either is occluded; (b) nutritious, to the upper end of the humerus, entering the bone under the outer head of the *triceps*; (c) muscular, to the long head of the *triceps*; (d) cutaneous, with the inner cutaneous branch of the musculo-spiral nerves; (e) cubital, descending through the outer head of the *triceps* which it supplies, and ending in the rete olecrani; (f) muscular, to the inner head of the *triceps*; (g) anterior terminal, which descends with the radial nerve between the *brachialis* and the *supinator longus* to anastomose with the radial recurrent in front of the outer epicondyle.

2. **Inferior profunda** arises below or with the last, and accompanies the ulnar nerve backwards and downwards through the inner intermuscular septum, lying on the inner head of the *triceps*, which it supplies, and ending

The branches of the brachial artery are:—

1. **Superior profunda**, which arises below the *teres major* and sinks with the musculo-spiral nerve between the long and inner heads of the *triceps* into the musculo-spiral groove, and, having descended externally between the *triceps* and *brachialis* and between *triceps* and *supinator longus*, ends behind the outer epicondyle in the rete olecrani. On its way it gives off the following branches—

(a) communicating, ascending be-

behind the inner epicondyle in the rete olecrani, one large branch anastomosing with the posterior ulnar recurrent.

3. **Muscular**, variable in number, but usually eight, passing to the several contiguous muscles.

4. **Nutritious**, arises usually from the upper muscular branch to the *brachialis* and descends in the nutritious foramen to supply the bone.

5. **Vas aberrans**, usually present, but often as a minute vessel not admitting of complete injection, arises close to or with the superior profunda, and descends over the median nerve, supplying the *biceps*. Its downward continuation, when present, joins either the radial artery, or more rarely the ulnar, and may be minute, moderate or large enough to replace and simulate the brachial which then appears to overlie the median nerve. When of moderate size it may replace the brachial origin of the radial (rarely the ulnar), giving rise to the common condition called the high bifurcation of the brachial; the aberrans occasionally communicates with the next.

6. **Anastomotica**.—This arises on the inner side about 6 cm. above the bifurcation and divides into two branches, an anterior which descends between the *brachialis* and *pronator teres* in front of the inner epicondyle to anastomose with the anterior ulnar recurrent, and a posterior which pierces the intermuscular septum to join the rete olecrani. The terminal branches of the brachial are radial and ulnar.

The brachial artery is liable to fœtal occlusions, in which case the aberrans or some other of its collateral anastomoses may dilate and replace the normal brachial.

Dissection.—Remove the fascia from the back of the arm, leaving the intermuscular septa attached to the bone, and, having examined the olecranon bursa, clean the *triceps*.

180. TRICEPS EXTENSOR CUBITI (figs. 389, 392).—The sole extensor of the elbow-joint occupies the back of the arm and arises by three heads. The **long or middle head** springs by a strong tendon, whose sheath is closely connected to the capsule of the shoulder, from the infraglenoid tubercle of the

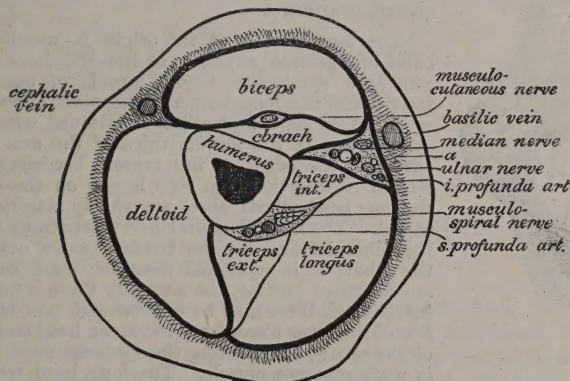


Fig. 395.—Section through arm at the level of the upper part of the insertion of the deltoid.

scapula and the axillary margin below it. The tendon is thick in front, but thins, and becomes mixed with fleshy fibres behind. Seen from behind it underlies the *teres minor*, but crosses the *teres major*, dividing the scapular triangle from the quadrilateral space, and, becoming tendinous, it unites with the other heads and is inserted by tendon into the upper surface of the olecranon.

The **outer head** (fig. 395) arises along a line which begins below the insertion of the *teres minor*, and descends thence to the upper edge of the musculo-spiral groove. Its origin is tendinous and closely connected below to

the intermuscular septum, which here forms a fibrous arch over the musculo-spiral nerve, from which the lower fascicles of the muscle arise. This part of

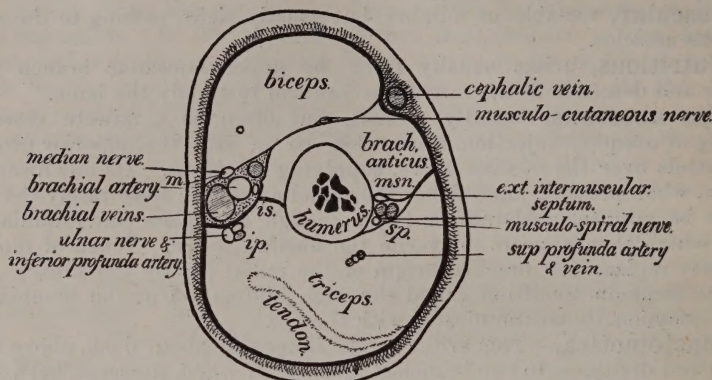


Fig. 396.—Section through arm below the insertion of the deltoid—is., internal intermuscular septum.

the muscle is closely joined to the long head below and inserted into the deep surface of its tendon and into its lateral extension.

The **inner head** arises from the whole breadth of the back of the humerus below the musculo-spiral groove, nearly as far as the condyles, its origin beginning narrow, below the insertion of the *teres major*, where it is attached to the back of the intermuscular septum. Most of its fibres pass obliquely into the deep surface of its tendon of insertion, but some are inserted independently into the olecranon.

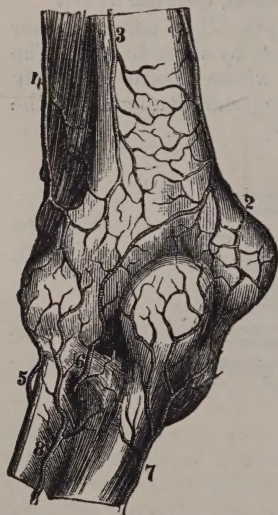


Fig. 397.—Rete olecrani, made up of the branches of (3, 4) the superior profunda and (2) the inferior profunda above anastomosing with (7) the posterior ulnar recurrent, (8) the interosseous recurrent, and (5) the radial recurrent arteries.

The long tendon at its origin is usually joined by a band of variable strength to the *latissimus dorsi*, the degenerated *dorsi-epitrochlearis* muscle of mammals. From the front of the long tendon some fibres of the *subscapularis* arise. This tendon of origin is flattened with its edges fore and aft, but at the middle third of the arm its aspect has changed, the edges of the muscle becoming lateral. The tendon of insertion (fig. 396) begins on the deep surface of the long head whose fibres are chiefly attached to its hinder aspect. The musculo-spiral nerve separates the outer from the inner heads. As the tendon passes over the back of the elbow it is separated from the weak capsule by loose areolar tissue and fat, but normally there is no bursa beneath it, although there may be one beneath the ulnar nerve. A few of its lower fibres from the inner head end in the capsule of the elbow, constituting the *subanconeus* of authors, which is not a separate muscle. The long head receives an independent nerve from the musculo-spiral (8c.); the branches of this nerve to the outer and inner heads come from the seventh and eighth cervical; the inner head is traversed by the long nerve to the *anconeus*.

Rete olecrani.—Around the olecranon and on the back of the capsule of the elbow is an irregular and much subdivided network of arteries (fig. 397) formed by branches of the two profunda arteries and the anastomotica from the brachial, and by the posterior ulnar recurrent and interosseous recurrent from below, which are disposed so as not to be interrupted by the tension of the superficial tissues in extreme flexion of the elbow, in which condition the branches of the brachial artery at its bifurcation are occluded by the pressure of the *pronator radii teres* muscle,

Dissection.—Remove the superficial fascia from the forearm as far as the wrist, reviewing and removing the nerves and vessels which have already been traced therein.

181. THE FASCIA OF THE FOREARM is a continuation of that of the arm, stronger behind than in front, and sending in sheaths to surround each muscle. Some of these are only areolar, but others are stronger and fibrous. Close to the epicondyles contiguous muscles arise from the opposed surfaces of these sheaths, rendering them with difficulty isolable and causing the sheaths to become very strong. Here they are called intermuscular septa. There are three such septa close to the inner epicondyle. Lower in the forearm the fascia sends a strong septum to be attached to the hinder edge of the ulna, and a weaker one along the outer ridge of the radius.

At the wrist posteriorly the transverse fibres of the forearm fascia become stronger and become supplemented by special fibres attached to the four thecal ridges on the lower end of the radius, to the styloid process of the ulna, and to the cuneiform and pisiform bone. This strong portion is called the **posterior annular ligament** (fig. 399), but it is only a specialised area of the fascia. Between the bony points of attachment of the ligament are six interspaces, each lined by a synovial sheath and transmitting tendons. (1) That on the outside of the radius in front of the styloid process transmits the *extensor ossis metacarpi* and *extensor pollicis minor* (*ib.*, 6); (2) that behind the styloid

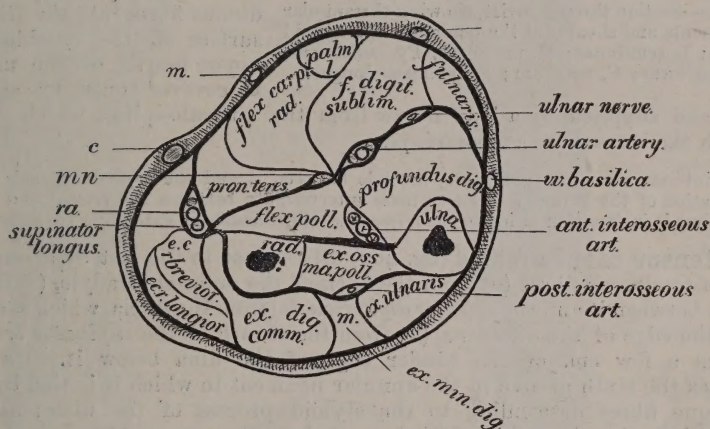


Fig. 398.—Section across the upper third of forearm. The fascial layers are shown by the thick black lines—*ra*, radial artery, with its companion veins; *m*, median vein; *c*, cephalic vein; *mn*, median nerve.

process transmits the *extensor carpi radialis longior* and the *extensor carpi radialis brevior* (*ib.*, 5); (3) that between the second and third thecal tubercles contains the *extensor pollicis major* (*ib.*, 4); (4) that between the third thecal tubercle and the radio-ulnar joint holds the *extensor communis digitorum* and *external indicis* (*ib.*, 3); (5) that behind the radio-ulnar joint is for the *extensor minimi digiti* (*ib.*, 2); and (6) that behind the styloid process of the ulna is for the *extensor carpi ulnaris* (*ib.*, 1).

Dissection.—Lay the hand with its palm downwards and separate the fingers widely, fastening them apart with tacks upon a piece of board. Remove the skin from the back of the hand and fingers, cleaning and leaving the branches of the radial and ulnar nerves, which divide on the back of the hand, in place. Remove also the fascia from the muscles arising from the external epicondyle.

182. MUSCLES OF THE FOREARM.—These muscles are twenty, twelve posterior, which are extensors and supinators, and eight anterior, which are

flexors and pronators. Each group consists of two layers, superficial and deep; seven of the former and five of the latter are superficial, the others are deep. Of the posterior series the most superficial and the deepest respectively are the two supinators; of the anterior series the two pronators. The superficial posterior muscles arise about the external epicondyle, and are supplied by the

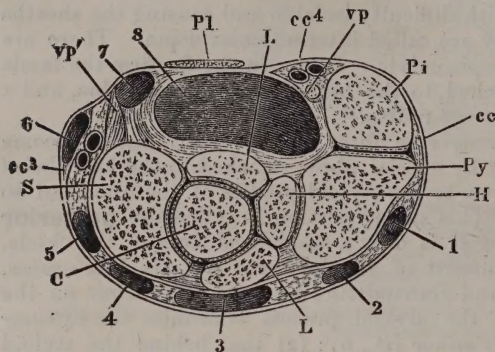


Fig. 399.—Section through wrist, showing the annular ligaments and sheaths of the tendons—S, scaphoid bone; L, semilunar; H, unciform; Py, cuneiform; Pi, pisiform; C, magnum; Pl, palmaris longus.

fascia, and supplied by a long nerve from the musculo-spiral, which descends through the inner head of the *triceps*.

The interosseous recurrent artery ascends between it and the *supinator brevis*. It is a segmentation of the primary extensor mass intermediate between the *triceps* and the next muscle, but is in function allied to the *triceps*, which it assists in extending the elbow.

Extensor carpi ulnaris (fig. 400) arises close to the last by a continuous sheet of tendinous fibres (*a*) from the back of the outer epicondyle, (*b*) from the septum between it and the *extensor digitorum*, (*c*) from the fascia, which is attached along the edge of the *anconeus*, (*d*) from the sheath of the *supinator brevis*, and (*e*) from a few cm. of the hinder edge of the ulna below it. Its tendon traverses the sixth groove in the annular ligament in which it is tied by a band of oblique fibres descending to the styloid process of the ulna; and it is inserted into the ulnar side of the base of the fifth metacarpal bone. A slender expansion from its tendon is continued to the extensor aponeurosis at the base of the little finger. It is a short-fibred muscle whose tendon begins in its substance. Its bursa extends from 1 cm. above the wrist to the fifth metacarpal. Its nerve is a branch of the posterior interosseous (8 c.).

Extensor minimi digiti (fig. 400) arises between the last and next muscles from the fascial sheath which surrounds it, by which alone it is attached to the outer epicondyle. It descends close to the *extensor communis digitorum*, but its tendon passes through a separate sheath in the annular ligament behind the lower radio-ulnar joint, and therein divides into two slips which end in the dorsal aponeurosis of the little finger. The radial division joins the little-finger tendon of the *extensor communis*.

It not uncommonly gives a tendon to the ring finger. The bursa of its sheath extends from the wrist to the middle of the fifth metacarpal. Its nerve from the posterior interosseous (8 c.) arises close to that for the next muscle, through which it passes.

Extensor digitorum communis (fig. 391) arises (*a*) from the lower part of the outer epicondyle, (*b*) from the fascia covering it, and (*c*) from the

musculo-spiral nerve; the superficial anterior about the inner epicondyle are supplied by the median and ulnar nerves. The posterior group are most conveniently examined in three series—superficial, deep, and marginal.

Anconeus (fig. 400).—A triangular muscle with short diverging fibres arises by tendon from the back of the outer epicondyle and from the back of the capsule of the elbow, and is inserted by fleshy and tendinous fibres into the triangular surface on the outside of the upper fourth of the ulna. It is covered only by skin and

intermuscular septa on each side. It divides into three slips on the back of the forearm, and these end in tendons at different levels.

The slip for the index finger is the most distinct, that for the middle finger usually becomes tendinous at the highest level, and often has a double tendon, the third slip also divides into two tendons.

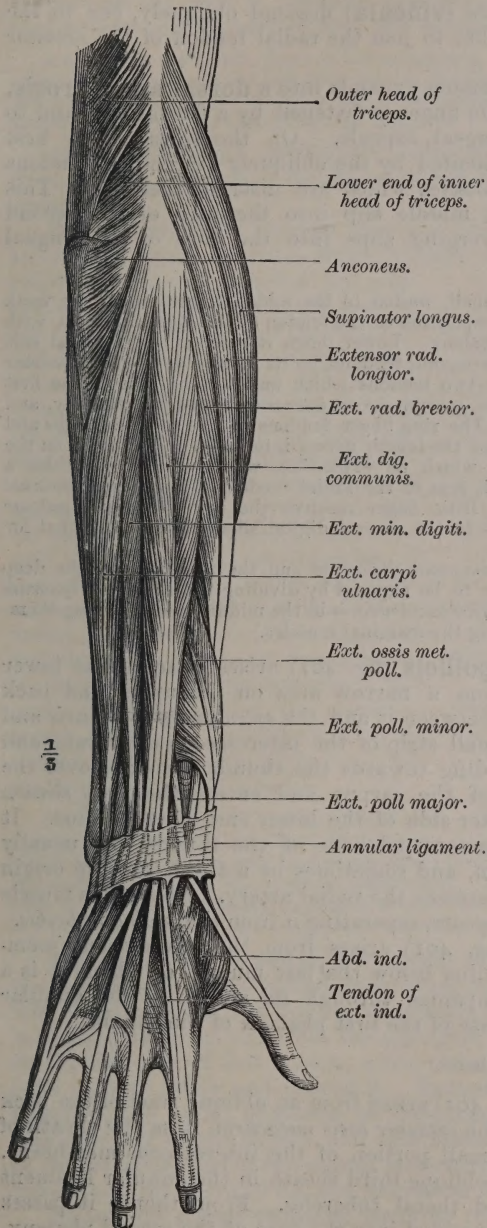


Fig. 400.—Muscles of back of forearm.

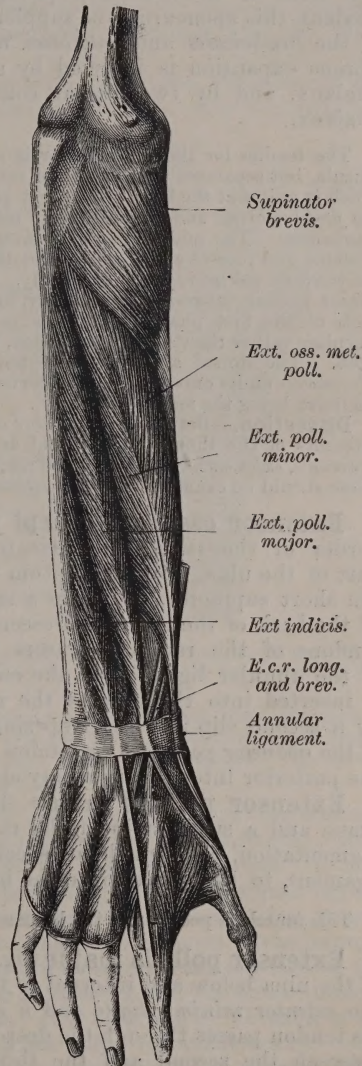


Fig. 401.—Deep muscles of the back of the forearm.

These pass through the fourth sheath in the posterior annular ligament behind the radius, and descend to the fingers. On the back of the hand the

tendons are joined together by transverse fibres, the band between the index and middle tendon being weak and transverse, while from the two tendons to the ring finger strong flat bands (*vincula*) descend obliquely, one to the tendon for the middle finger, the other to join the radial tendon of the *extensor minimi digiti*.

On the back of each finger the tendon expands into a **dorsal aponeurosis**, which at each side of the base of the finger is fastened by a flat lateral band to the sides of the metacarpo-phalangeal capsule. On the sides of the first phalanx this aponeurosis is supplemented by the obliquely descending tendons of the *lumbricales* and *interossei* muscles which are inserted thereinto. This fibrous expansion is inserted by a middle slip into the base of the second phalanx, and by two lateral converging slips into the base of the ungual phalanx.

The tendon for the index finger is small, united to the middle-finger tendon by weak *vincula*, but separated from it by the interposition of the tendon of the *extensor indicis*, with which it unites at the base of the first phalanx. Lower down it receives on its radial side the *first lumbrical* and the first *dorsal interosseous* tendons, on its ulnar side the first *palmar interosseous*. The middle finger receives two tendons which unite at the base of the first phalanx, and receive a *lumbricalis* and the second *dorsal interosseous* tendon externally, and the third *dorsal interosseous* internally. The ring-finger tendons receive the *lumbricalis* and second *palmar interosseous* externally, and the fourth *dorsal* internally. They unite on the back of the first phalanx, previous to which an expansion, which closely resembles a *vinculum* rather than a separate tendon, is sent to the radial tendon of the *extensor minimi digiti*. The dorsal aponeurosis of the little finger receives the *lumbricalis* and *palmar interosseous* on its outer side. The nerves to the several digital slips are separable, that for the index being the most so (7 c.).

Dissection.—Between the *extensor communis digitorum* and the next muscles the deep extensors of the thumb emerge, and are to be exposed by dividing the *extensor digitorum communis*, *extensor minimi digiti*, and *extensor carpi ulnaris* in the middle, and reflecting them. These should be examined before dissecting the marginal muscles.

Extensor ossis metacarpi pollicis (fig. 401) arises close to the lower border of the *supinator brevis* from a narrow area on the upper and back part of the ulna, from the septum between it and the *extensor carpi ulnaris* and the short supinator, and from a small strip of the interosseous membrane and of the back of the radius. Descending towards the thumb it crosses over the tendons of the radial extensors of the carpus and enters the first sheath of the annular ligament on the outer side of the lower end of the radius. It is inserted into the base of the metacarpal bone of the thumb, and usually by a second slip into the trapezium, and sometimes by a third into the origin of the *abductor pollicis*. Its tendon crosses the radial artery. Above this muscle the posterior interosseous artery appears, separating it from the *supinator brevis*.

Extensor pollicis minor (fig. 401) arises from the interosseous membrane and a small strip of the radius below the last muscle, of which it is a segmentation, and which it accompanies through its sheath in the annular ligament, to be inserted into the base of the first phalanx of the thumb.

This muscle is peculiar to the human hand.

Extensor pollicis major (fig. 401) arises from an oblique tract of the back of the ulna below and internal to the *extensor ossis metacarpi*, from the sheath of the *extensor minimi digiti* and a small portion of the interosseous membrane. Its tendon passes through the deep oblique third sheath in the annular ligament between the second and the third thecal tubercles. From thence it passes along the back of the thumb to be inserted into the base of the second phalanx. Its tendon is superficial and becomes prominent at the base of the extended thumb; the hollow of the "snuff-box" lying between it and the tendon of the *extensor minor*.

Extensor indicis (fig. 401) arises below and internal to the last from a

narrow strip of the back of the ulna and of the interosseous membrane. Its tendon passes in the fourth sheath, with the *extensor digitorum communis*, appears on the back of the hand between the indicial and medial tendons of that muscle, and is inserted with the *common extensor* into the index finger.

A tendon to the middle finger is not uncommon, while occasionally a separate intermediate belly between this and the last gives rise to tendons both for the thumb and index finger. The bursa sheathing the tendon of the *extensor major* and that of the *radial extensors* communicate as they cross each other (fig. 402).

183. MARGINAL MUSCLES.—The group of marginal muscles clothing the external epicondyle should next be examined, beginning with the most superficial.

Supinator radii longus (figs. 400, 403) forms the outer boundary of the antecubital fossa, and arises from the upper two-thirds of the external condyloid ridge of the humerus below the musculo-spiral groove. It becomes tendinous in the middle third of the forearm, and is inserted into the ridge which forms the upper margin of the first groove at the lower end of the radius (p. 148). It is covered by skin and fascia, and the lowest part of its insertion is overlapped by the tendon of the *extensor ossis metacarpi pollicis*. It lies on the humerus, *brachialis*, the next pair of muscles, and the insertion of the *pronator teres*. It has the musculo-spiral nerve and radial recurrent artery along its inner side in the arm, and the radial artery and nerve along its inner side in the forearm. Its nerve (6 c.) arises from the musculo-spiral before its division, and it is nourished by branches of the superior profunda and radial arteries.

The *supinator* is a curiously-twisted muscle; its origin is a vertical line from which the upper fibres pass backwards and the lower forwards, so that the lower part of the muscular belly is transversely compressed. From the lower two-thirds of the hinder edge of this muscle a fascial expansion is sent off which covers the extensors. This muscle is a flexor of the elbow and a supinator when the hand is fully pronated.

Extensor carpi radialis longior (fig. 400), shown by drawing forward the *supinator*, is fusiform, and arises from the lower third of the external condyloid ridge and from the septum between it and the succeeding muscle. It soon becomes tendinous, underlies the *supinator*, but being broader, projects beyond the hinder edge of that muscle, while the next muscle, which underlies it, projects in turn below and behind it. Entering the second groove in the annular ligament, the radial extensors of the carpus are crossed by the tendons of the *long extensors* of the thumb, and this muscle is inserted into the outer tubercle at the proximal end of the second metacarpal. It is supplied by a branch of the musculo-spiral nerve (6 c.), and nourished by the radial recurrent artery.

Extensor carpi radialis brevis (fig. 400) is thicker and shorter, being a rhomboidal muscle in structure, composed of short fibres passing obliquely between the tendon of origin and that of insertion. It arises from the outer epicondyle, the external lateral ligament and the intermuscular septa which divide it from the last and from the *supinator brevis* and *extensor digitorum*.

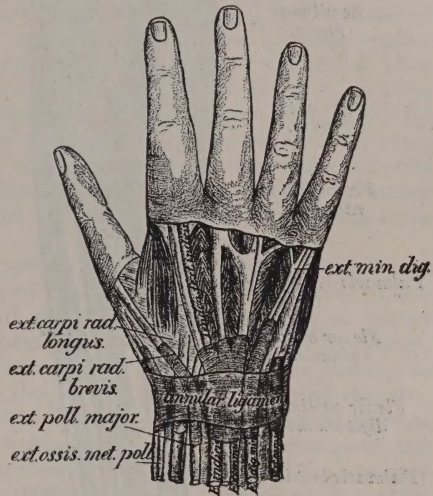


Fig. 402.—Sheaths of tendons on back of the wrist.

It descends under cover of the last muscle, and its tendon is, with it, crossed by the extensors of the thumb. It enters the second groove in the annular ligament, lying at first under and then internal to the long radial extensor, and is inserted into the styloid process of the third metacarpal (fig. 402).

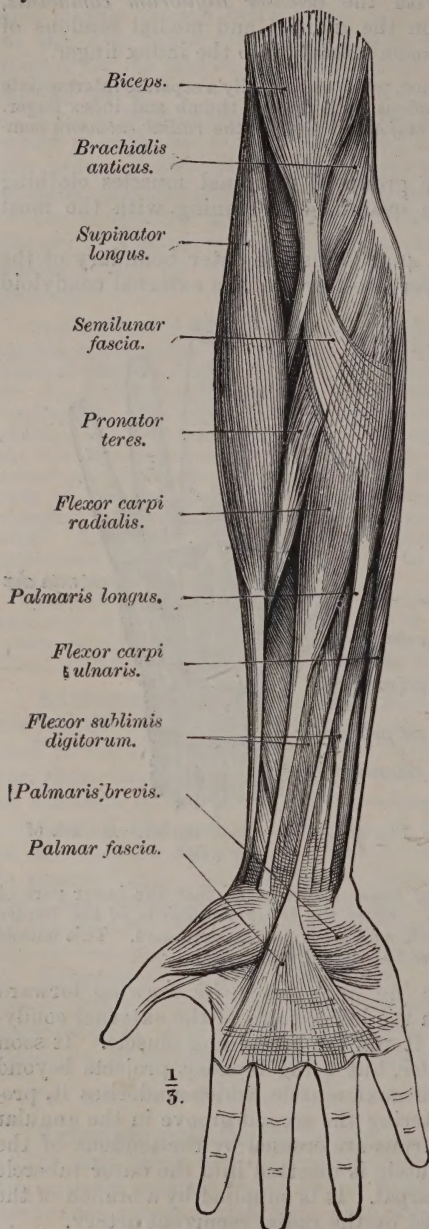


Fig. 403.—Muscles of the front of the forearm.

The two radial tendons are enclosed in an upper synovial sheath as they pass under the thumb tendons; thereby they can glide on the radius and under these. A lower sheath, which may communicate with the upper, surrounds them as they pass through the annular ligament, and extends to the metacarpal bones; a small and usually separate bursa underlies each tendon immediately before its insertion.

Dissection.—The arm is now to be placed on its back with the hand supine, but is not to be fixed yet in this position.

§ 184. THE FRONT OF THE FORE-ARM—Antecubital fossa.—This tri-

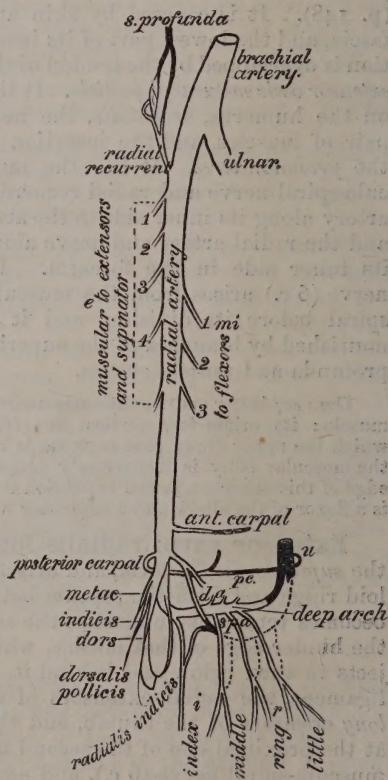


Fig. 404.—Diagram of the course and branchings of the radial artery.

angular space in front of the bend of the elbow is bounded externally by the *supinator longus*, internally by the *pronator teres*, and its base is a transverse

line from the outer to the inner epicondyle. It contains the *biceps* tendon externally, the brachial artery intermediately, and the median nerve internally. In the external bicipital sulcus the musculo-cutaneous nerve, and deeper still, the musculo-spiral nerve, and the anastomosis between the anterior branch of the superior profunda and the radial recurrent arteries, appear. In the inner bicipital sulcus is the communication between the anastomotica and the anterior ulnar recurrent arteries. In the floor of the space the insertions of the *biceps* and *brachialis* can be seen.

185. THE RADIAL ARTERY is the vessel supplying the preaxial region of the limb. It is the smaller terminal branch of the brachial (p. 288), but descends to the wrist in the same line as its parent, lying for the most part superficially, only covered by skin and fascia; and hence it is the most convenient vessel wherein to examine the arterial pulse. It has for its whole length the *supinator longus* to its outer side; on its inner side for the upper third is the *pronator teres*, for the lower two-thirds the *flexor carpi radialis*. These muscles overlap it a little above, and serve to guide the surgeon in seeking for the vessel. Its nerve lies to its outer side for the upper three-fourths of the forearm, and the two deep radial veins (*venæ comites*), which lie one on each side, are united by many cross branches over the artery, ending above in the outer brachial vein. The radial artery lies on the *biceps* tendon, *supinator brevis*, *pronator radii teres*, the radial origin of the *flexor sublimis digitorum*, the *flexor pollicis*, the *pronator quadratus*, and the lower end of the radius. Its vasomotor filaments come from the radial nerve.

Having reached the wrist, the radial artery turns backwards on the external lateral ligament of the joint, on the back of the scaphoid and trapezium, to the interspace between the first and second metacarpal bones. Here it passes between the two heads of the *abductor indicis* and enters the palm of the hand, becoming the deep palmar artery—to be subsequently traced. While passing to the back of the wrist it is crossed by the three extensor tendons of the thumb.

The branches of the radial artery, in the forearm, are:—(1) **Radial recurrent** which runs first outwards and then descends along the inner edge of the *supinator longus*, which it supplies, anastomosing with a branch of the superior profunda between that muscle and the *brachialis anticus*. It sometimes separates the radial from the posterior interosseous nerves. (2) **Muscular**, about nine in number passing to the *supinator longus* and *brevis*, to the *extensor carpi radialis longior* and *extensor brevior*, to the *flexor pollicis*, and sometimes to the *pronator radii teres*.

Close to the wrist its branches are:—(3) **Superficialis volæ**, which crosses and nourishes the muscles which form the thenar eminence, and anastomoses with the superficial palmar arch (p. 304); (4) **anterior carpal**, a small branch to the rete arterius carpi; (5) **posterior carpal**, a larger branch which passes back under the extensor tendons to the posterior carpal rete. (6) **Metacarpal**, crosses the back of the second metacarpal bone, sending a perforating branch between the heads of the second *dorsal interosseous*, and then descends to the back of the cleft between the index and middle fingers where it is lost in fine branches. (7) **Dorsalis pollicis**, one or two branches descending parallel to the ulnar edge of the thumb metacarpal on the hinder side of the *abductor indicis* to supply the skin of the cleft thumb. (8) **Dorsalis indicis**, often absent, passes superficially in like manner along the radial side of the second metacarpal. Beneath the abductor indicis the radial gives off—(9) **princeps pollicis**, a large branch which descends between the abductor indicis and adductor pollicis to the palmar surface of the thumb on its ulnar side; (10) **radialis indicis**, which descends in the same interspace to the radial side of the index finger. (11) **The deep palmar**, the continued trunk of which will be seen subsequently (p. 310).

both digits on their opposed sides; (c) a branch to the opposed sides of the index and middle fingers, supplying the skin of the back of these; and (d) a communicating branch which joins the dorsal branch of the ulnar, and with it gives a common supply to the cleft between the middle and ring fingers.

There are about twenty-five Pacinian corpuscles on these nerves, especially on its index and thumb-branches. Their distribution is shown in fig. 379.

(12) **The posterior interosseous nerve** is chiefly, if not exclusively, motor. It gives off a branch to the *extensor carpi radialis brevis*, and then sinks through the thickness of the *supinator brevis* muscle which it supplies, emerging posteriorly between its lower border and the upper edge of the *extensor ossis metacarpi*; here it gives off branches to the *extensor digitorum communis*, *extensor minimi digiti* and *extensor carpi ulnaris*, and continues its course over the extensors of the thumb, which it supplies. A deep branch pierces the *extensor pollicis major*, and passes to the wrist, on the back of which it becomes thick and reddish, forming a pseudo-ganglion from which five dichotomously branching filaments pass downwards to terminate in the intermetacarpal ligaments (fig. 405, *psg*).

187. THE POSTERIOR INTEROSSEOUS ARTERY (p. 303), having passed through the interosseous space, appears with the last-named nerve between the *supinator brevis* and the *extensor ossis metacarpi*, it sends branches to each muscle, and a large recurrent branch to the rete olecrani, and, finally descending between the superficial and deep muscles, ends below in the rete carpal dorsale.

188. SUPINATOR BREVIS (fig. 401).—This deep muscle is exposed by removing the extensor muscles from the outer epicondyle. It arises from a small portion of the lower and back part of the epicondyle, from the external lateral ligament, from the orbicular ligament of the radius, and from the rough ridge bordering the irregular depressed space on the ulna below the lesser sigmoid cavity. The fibres wind forwards and downwards, and are inserted into the outer surface of a little more than the upper third of the radius between the two oblique lines.

This short-fibred muscle is tendinous at its origin and on its surface, fleshy beneath and at its insertion. It embraces the radius for nearly two-thirds its circumference. Not uncommonly, separate slips are detached from it which are inserted into the orbicular ligament, and into the bursa over the *biceps* tendon when such exists.

189. DISSECTION.—Turn the hand on its back and fasten the fingers apart by a tack in each finger. Remove the fascia from the muscles arising from the inner epicondyle, and divide the skin of the palm vertically to the base of the middle finger. Make a transverse incision at the base of the fingers, and reflect the flaps of palmar skin, noting the lines of attachment of the fibres which tie the skin to the fascia along the palmar folds: clean the surface of the fascia and of the *palmaris brevis*, the short transverse muscle inserted thereinto from the hypothenar skin, removing the granular fat which is embedded in it. Beneath the skin the palmar cutaneous branches of the median and ulnar nerves are to be sought for and traced over the front of the wrist (p. 306), and the muscles from the inner epicondyle are next to be examined.

THE ANTERIOR MUSCLES are five superficial and three deep.

Pronator radii teres (fig. 403) arises (1) superficially from the inner supracondyloid ridge, from a fascial septum between it and the next muscle, and from the supracondyloid ligament when present; (2) deeply by a thin tendon from the inner side of the coronoid process of the ulna. The median nerve separates and innervates (6c) these heads, sending off a branch which divides into two for this purpose, and enters the muscle on its outer and deep surface. Descending obliquely radialwards, it is inserted by tendon into the oblique ridge and the pronator impression on the outer side of the radius.

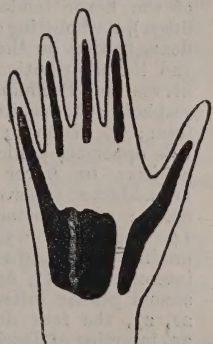


Fig. 406. — Synovial sheaths of front of wrist.

It is covered by fascia and the superficial veins, crossed by the radial artery and nerve, and its insertion is overlapped by the *supinator longus* and by the radial extensors of the carpus, as it winds round the bone. It lies on the *brachialis anticus*, on the ulnar artery (which its deep head separates from the median nerve), the *flexor sublimis digitorum*, and the radius. It forms the inner boundary of the antecubital fossa.

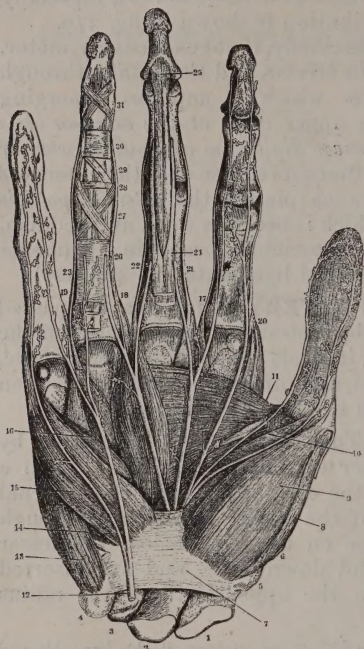


Fig. 407.—Dissection of the hand, showing the structure of the sheath of the flexor tendon (in the ring finger), the splitting of the superficial flexor tendon (in the middle finger), and the distribution of the digital nerves and Pacinian corpuscles—1, scaphoid; 2, semilunar; 3, cuneiform; 4, pisiform; 5, trapezium; 6-8, opponens pollicis; 9, abductor pollicis; 10, flexor brevis pollicis; 11, adductor transversus; 12, ulnar nerve; 13, abductor minimi digiti; 14, opponens; 15, flexor brevis minimi digiti; 16-19, third palmar interosseous; 17, first palmar; 18, second palmar interosseous; 20, 21, 22, 23, the four dorsal interossei; 25, insertion of flexor profundus; 26, 27, 28, 29, 30, 31, parts of the sheath of the flexor tendons.

a strong white fibrous triangular structure—the **palmar fascia**. This consists principally of longitudinal fibres, which are crossed, especially below, by transverse fibres which are more deeply placed. At the edge of the thenar and hypothenar eminences, this expansion suddenly becomes thinner, only a weak areolar layer continuous with the transverse fibres being continued thereover. Towards the fingers the fascia divides into four slips which are

It pronates the hand and flexes the elbow. The coronoid head is proportionally larger and more separable in the fetus, and is the rudiment of a deep ulno-radial muscle. It is probably saved from disappearance by being functional as a pronator in extreme flexion of the elbow.

Flexor carpi radialis (fig. 403) overlaps the last, and arises tendinously from the front of the inner epicondyle, and from two septa which divide it from the foregoing and from the *flexor sublimis digitorum*; descending obliquely outwards, it ends in a long tendon, which is flat above, narrowing towards the wrist, and lies internal to the radial artery for the lower half of the forearm. It dips deeply at the wrist beneath the short muscles of the thumb to enter the groove in the trapezium which is converted into a canal by special transverse fibres. It is inserted into the anterior tubercle of the base of the second metacarpal, and by a few fibres into the anterior basal tubercle of the third. A bursa underlies this tendon as it crosses the scaphoid and trapezium. Its nerve, a branch of the median (6 c.), enters its deep surface. It flexes the wrist and elbow and abducts the hand.

Palmaris longus (fig. 403).—Small, fusiform and variable, occasionally absent, arises from the intermuscular septum between the last muscle and the *flexor sublimis digitorum*, and by a few fibres from the inner epicondyle. Its nerve, a branch of the median (8 c.), passes into its deep surface through the *flexor sublimis*. It becomes tendinous at a little higher level than the last muscle, nearly parallel to which its slender flattish tendon descends to the middle of the wrist. Here it becomes superficial, the overlying fascia being weak, the deeper being much stronger. Entering the palm the tendon thickens and expands into

tied together by transverse fibres along the *linea mensalis*. Each of these digital slips descends towards its finger, and should be traced by reflecting the skin from the front of the first joint; its superficial fibres pass to the skin along the *linea mensalis*, and to the transverse fold at the base of the finger. The deeper fibres divide into two lateral fascicles which are inserted into the sides of the fibro-cartilages of the metacarpo-phalangeal capsules. Opposite and above the heads of the metacarpals, these lateral slips are attached by deep processes to the margins of the short triangular palmar areas on the metacarpals, thus bounding separate sheaths for the digital tendons. Between these sheaths are the channels in which the digital nerves and vessels and the *lumbrical* muscles pass to their fingers.

Between the digital slips and closely attached to the skin of the webs of the fingers are transverse fibres forming the **superficial transverse interdigital ligaments**. These cross over the vessels and nerves, and are laterally attached to the skin over the outer margin of the hand, and to the fifth metacarpal bone.

The superficial aspect of the fascia sends off many fibres to the skin as has already been seen; from its deep surface two weak lateral septa dip in to be attached to the fascia sheathing the thenar and hypothenar eminences, and through these to the third and fifth metacarpals. A thin synovial fold is reflected from its deep surface to the ulnar side of the flexor tendon for the middle finger. These deep connections, though weak, serve as limits for sub-fascial abscesses.

Palmaris brevis (fig. 403) consists of several short transverse fleshy fasciculi, which arise from the inner edge of the palmar fascia, and are inserted into the skin of the hypothenar eminence below the pisiform bone. It can corrugate the skin, and is supplied by a branch of the ulnar nerve (1 *d.*).

The *palmaris longus* is the degenerated perforated flexor of the first phalanges, and the palmar fascia is a modified expansion of its tendon.

Flexor carpi ulnaris (fig. 407) arises (1) by a flat tendon from the back of the inner epicondyle, and (2) by a broad fascial origin from the inner side of the olecranon, and from the fascia of the forearm as it is attached along the upper two-thirds of the ulna. It is a penniform muscle, whose tendon of insertion begins at its anterior margin high in the forearm, receiving fleshy fibres nearly to the wrist. It is inserted into the pisiform bone and the piso-metacarpal ligament (§ 160). The ulnar nerve passes between its heads, sending to each a separate nerve (8 *c.*, 1 *d.*).

As the nerve lies between the inner epicondyle and the olecranon, it has often a small bursa between it and the former, and is bound down by transverse fibres, which are occasionally muscular, the **epitrochleo-anconeus**, a derivative of this muscle, and supplied like it by the ulnar nerve.

The ulnar artery and nerve lie for the lower two-thirds of the forearm along the outer border of this muscle, which serves to guide the surgeon thereto. It lies on the *flexor profundus digitorum* and ulnar nerve. It is an adductor and flexor of the wrist.

Dissection.—Divide in the middle and reflect the *flexor carpi radialis* and *palmaris longus*; detach the palmar fascia from its deeper attachments in front of the wrist and reflect it towards the fingers, divide also the skin of the middle and ring fingers along their middle lines and reflect it from each finger in two flaps, noting in doing so, the strong, but not clearly bordered **phalangeo-cutaneous ligaments**, which pass from the sides of the base of the first phalanx of each finger to the skin on the back of the second, and from the sides of the base of the second phalanx to the deep surface of the skin covering the pulp of the end of the finger. Remove the fat that overlies the sheath of the flexor tendons in the middle finger. This sheath is a tube, bounded behind by the bones, in front by a complex arrangement of white fibrous bands, which from above downwards are:—(1) **Superior vaginal band**, strong and transverse, crossing the upper half of the first phalanx; (2) **superior crucial band**,

composed of two weaker X-like bands at the distal end of the first phalanx; (3) **middle vaginal** band, a slender transverse slip across the level of the first interphalangeal joint; (4) **oblique** band, passing downwards and inwards on the upper end of the second phalanx; (5) **inferior vaginal**, over the middle of the second phalanx; and (6) **inferior crucial**, over the second interphalangeal joint. Between these bands the sheath is weak and indefinite (fig. 407).

In front of the wrist beneath the *palmaris* tendon is the superficial layer of the anterior annular ligament, attached internally to the pisiform, where it is continuous with the inner end of the posterior annular ligament and externally to the tubercle of the scaphoid and trapezium. This part is covered by the origins of the thenar muscles. Open one digital sheath for its whole length to expose the contained tendons.

Flexor sublimis digitorum (fig. 403) arises (1) by a large tendinous and fleshy head from the lowest part of the inner epicondyle, the capsule of the elbow, the inner side of the coronoid process, and from the septa which intervene between it and the two carpal flexors; (2) by a thin, broad tendon, from the anterior oblique ridge of the radius (fig. 236). The median nerve separates these heads, and the ulnar nerve separates its hinder edge from the *flexor carpi ulnaris*. Shortly below its origin the humeral head divides into a superficial and a deeper portion. The former again subdivides into two bellies, an outer, which unites with the radial head and descends to the wrist, becoming tendinous, to be inserted into the middle finger; the inner passes to the ring finger, is closely tied to the deeper portion, and becomes tendinous sooner than the outer. The deeper portion also subdivides into two, an outer, usually digastric, passing to the index finger, and an inner, much smaller, arising from the central tendon of the outer and passing to the little finger.

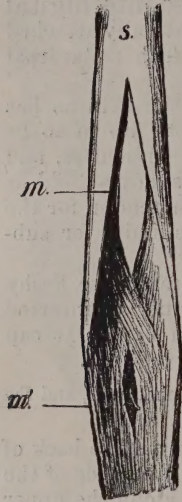


Fig. 408.—Splitting of the tendon of the flexor sublimis of the index finger.

At the wrist the tendons are arranged—two for the medial digits in front, and two for the lateral digits behind. They pass under the annular ligament into the palm, beneath the branches of the median nerve and ulnar artery. Each tendon enters its separate digital sheath below, and divides into two lateral slips (fig. 408, *m*) which begin to diverge from each other opposite the middle of each first phalanx, allowing the tendon of the deep flexor which underlies it to appear on the surface. The two slips of the superficial tendon are folded around the sides of the deep tendon, and finally pass underneath it to reunite in front of the bone (*ib.*, *m'*), but each slip has become twisted, so that the edges by which these slips come together are the continuations of the original lateral edges of the tendons, while the inner edges of the two split portions become the outermost. As they reunite the contiguous fibres of the tendon cross each other, the others slightly diverge, and the tendon again divides into two slips, which are inserted into the lateral ridges of the second phalanges of each finger. A villous, toothed, fibrous and synovial lamina, fills the angle above the junction of the halves of the tendon. The other synovial arrangements will be seen in relation to the *flexor profundus* (§ 193).

The *flexor sublimis* is supplied by the median nerve, and the branches to its several digital bundles can be easily separated (7, 8 c., 1 d.), the twig to the radial head being independent (8 c.). It is nourished by branches of the ulnar artery.

Dissection.—Separate the flexor sublimis from the median nerve which adheres to its deep surface and radial margin, and divide the muscle at the lower third of the forearm, reflecting it upwards.

190. THE ULNAR ARTERY now exposed is the larger terminal branch of

the brachial (p. 288), beginning opposite the head of the radius, and descending at first in a curved line beneath the *pronator teres*, *flexor radialis*, *palmaris longus*, and *flexor sublimis*. It then descends directly for the lower half of the forearm between the *flexor sublimis* externally, and the *flexor carpi ulnaris* internally, overlapped by the latter, and so closely bound down, that its pulsation is seldom palpable during life.

Entering the palm external and close to the pisiform bone through a canal between the layers of the annular ligament it divides into its two terminal branches. It lies on the *brachialis anticus* and the *flexor profundus digitorum*, is crossed above obliquely by the median nerve, from which it is separated by the deep head of the round pronator, and is accompanied on its inner side by the ulnar nerve for the lower two-thirds of the forearm. The *flexor sublimis* separates this nerve from the artery for its upper third. The two deep ulnar veins which accompany the artery are united by frequent cross branches, the outer vein ends in the inner brachial vein, the inner in the mediana profunda. Its vasomotor filaments come from the median above, and from the ulnar palmar nerve below.

The branches are:—1. **Anterior ulnar recurrent**, which ascends beneath the edge of the *pronator teres*, on the *brachialis anticus*, supplying both muscles and anastomosing with the anastomotica.

2. **Articular**, piercing the front of the capsule of the elbow external to the *brachialis anticus* to supply the joint. 3. **Posterior ulnar recurrent**, much larger, arises under the *flexor sublimis*, and ascends between the heads of the *flexor carpi ulnaris*, behind the inner condyle, by the side of the ulnar nerve, to end in the rete olecrani. It supplies the *flexor ulnaris* and *sublimis* and the *palmaris longus*. 4. **Interosseous**, a short trunk, which descends towards the opening between the oblique and the interosseous ligaments. The posterior has been already traced (§ 187), and should now be reviewed. The anterior interosseous descends on the front of the interosseous membrane, to which it is tied by an areolar sheath, between the *flexor pollicis* and the *flexor profundus digitorum*, to the upper edge of the *pronator quadratus*; here it

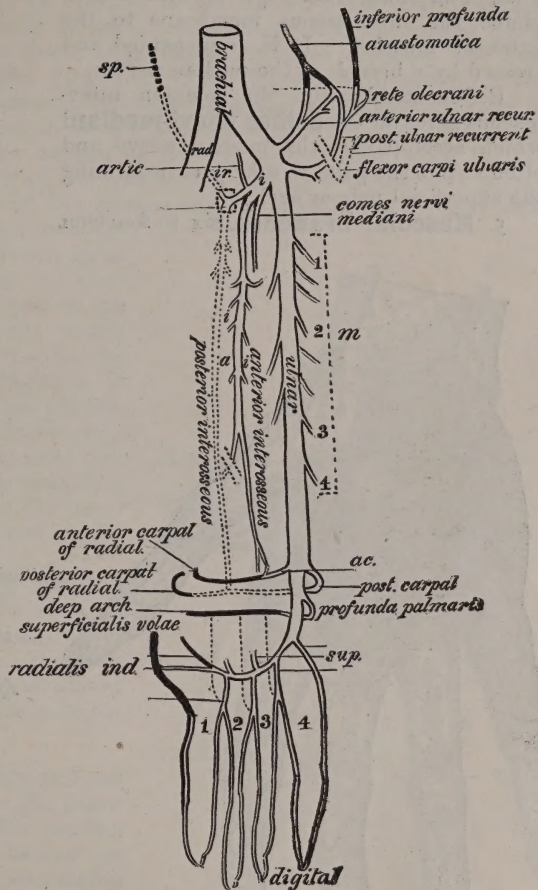


Fig. 409.—Diagram of the course and branches of the ulnar artery.

divides into an anterior branch, which descends to supply that muscle, ending below in the anterior carpal rete, and a larger posterior branch which passes backwards in a membranous canal to the posterior carpal rete. The anterior interosseous in its course sends branches to the deep flexor muscles, supplies the nutritious branches to the radius and ulna, and fine rami perforantes which pierce the interosseous membrane to the extensor muscles. It is accompanied and crossed by a branch of the median nerve.

Before its division the common interosseous gives off the **comes nervi mediani** which accompanies the median nerve and often enters the palm to take part in forming the superficial palmar arch.

5. Muscular branches, six to fourteen

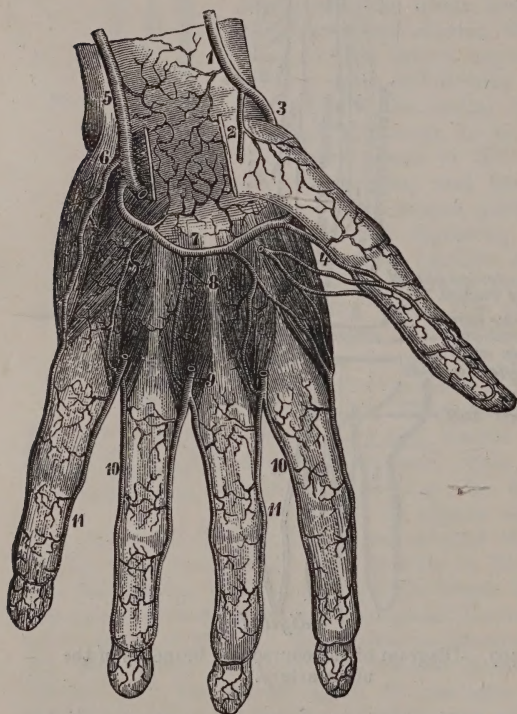


Fig. 410.—Deep palmar arch of arteries—1, 3, radial artery; 2, superficial volæ; 4, princeps pollicis; 5, ulnar artery; 8, third metacarpal; 9, common digital artery; 10, 11, lateral digital arteries.

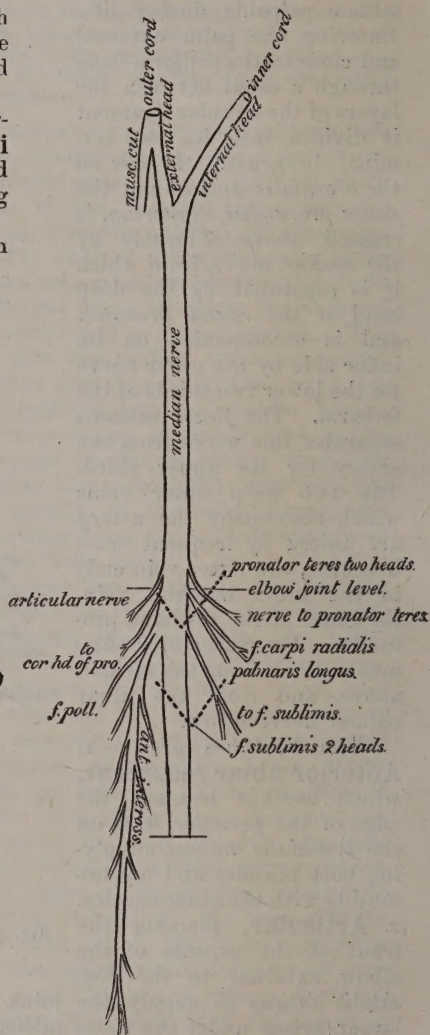


Fig. 411.—Diagram of median nerve as far as the middle of the forearm.

pass to the neighbouring superficial muscles. 6. **Metacarpal**, arises above the pisiform and passing backwards to the dorsal rete, sends a marginal branch along the ulnar side of the little finger.

7. **Carpals** are usually two small anterior, and two or three posterior branches passing to their respective retia. 8. **The superficial palmar**, the larger terminal branch crosses the palm beneath the palmar fascia lying on the

median and ulnar nerves and the flexor tendons, forming an arch whose concavity is directed upwards. It first descends along the edge of the hypothenar eminence parallel to the *linea vitalis*, midway between which and the *linea cephalica* it turns outwards towards the web of the thumb, where it ends by anastomosing either with the *radialis indicis* or with the *superficialis volæ* or both. From its upper or concave border ascend a few small branches to the carpal bursa and palmar fascia, anastomosing with the *comes nervi mediani*; from its convexity three large digital arteries descend, the first to the interspace between the ring and little fingers, bifurcating at the mid-point of the *monticulus saturni*, its branches going to the opposed sides of these fingers; the second descends to the interspace between the middle and ring fingers, bifurcating in the middle of the *monticulus*; the third in like manner descends to the middle of the *monticulus*, and its two branches supply the cleft between the index and the middle fingers. Before its division each digital branch receives a branch from the deep arch and one from the dorsal metacarpal artery. In each finger the marginal digital arteries descend towards the tip anastomosing with the dorsal vessels of the finger, and joining each other by arched cross anastomotic branches at each joint over the sheath of the tendon. At the last phalanx they divide into dorsal branches, which form a close network under the nail, and palmar branches, which form a large arch below the insertion of the deep flexor tendon and supply the pulp of the finger.

9. The **communicating branch** (fig. 410, 7) sinks between the *abductor* and the *flexor brevis* of the little finger to join the deep palmar arch. It generally gives off the innermost digital artery (*ib.*, 6) to the inner side of the little finger, close to its origin.

191. MEDIAN NERVE (figs. 411 and 412).—This and the ulnar are the flexor nerves of the upper limb. The median is peculiar in structure as having its component strands plexiform, not parallel (fig. 375). It gives no branch in the arm, but as it enters the antecubital fossa internal to the brachial artery it gives off two branches to the *pronator teres* and those to the *flexor radialis*, *flexor sublimis*, and *palmaris longus*, and then sinks between the heads of the *pronator teres*. Here it gives off the anterior interosseous branch which first lies external to, then crosses, then recrosses its artery, and supplies the *flexor pollicis*, part of the *flexor profundus*, and the *pronator quadratus*. It also sends off minute filaments to the interosseous membrane, to the radius and ulna, and to the front of the wrist-joint. The median often gives a communicating branch to the ulnar, along the ulnar artery, and then sinks between the heads of the *flexor sublimis*, descending nearly in the middle line of the forearm, closely attached to the deep surface of that muscle, appearing at the wrist beneath the *palmaris longus* and between the tendons of *flexor*

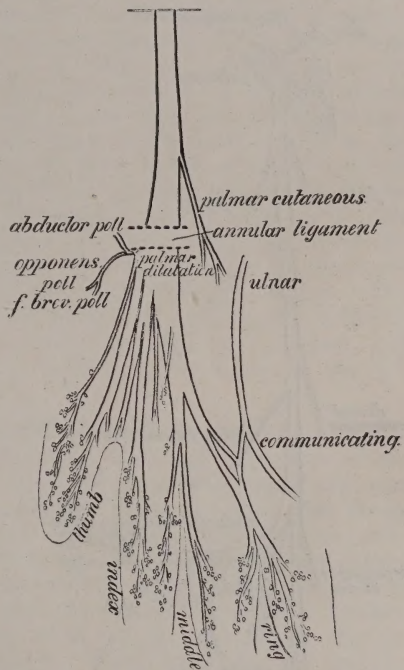


Fig. 412.—Diagram of median nerve in the hand.

radialis and *flexor sublimis*. About 5 cm. above the wrist (fig. 412) it gives off a palmar cutaneous branch (7 c.), which descends over the palmar fascia to supply the skin of the palm. The median nerve passes under the annular ligament, becoming swollen, pink, and flattened, and sends off deep branches to the superficial muscles of the ball of the thumb (*abductor* and *opponens pollicis* and superficial head of *flexor brevis*), a superficial branch to the radial margin of the thumb (6 c.), a cutaneous branch to the ulnar side of the thumb and its web (6, 7 c.), a cutaneous branch to the radial side of the index, sending the nerve to the first *lumbricalis* (6, 7 c.). These four branches sometimes come off by a common trunk. The branch to the *abductor pollicis* is recurrent. The next branch passes to the cleft

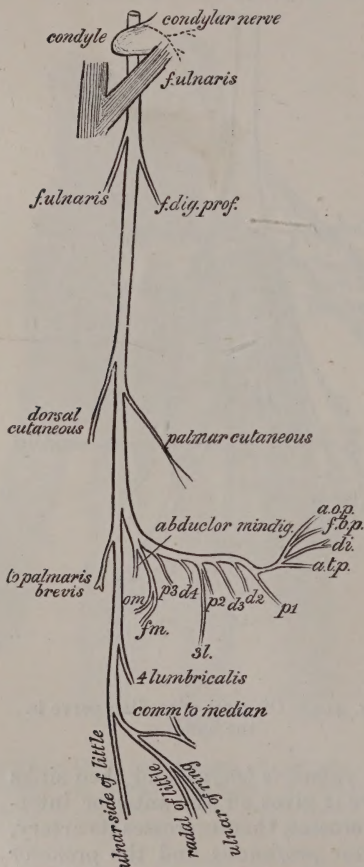


Fig. 413.—Diagram of the course and branches of the ulnar nerve.

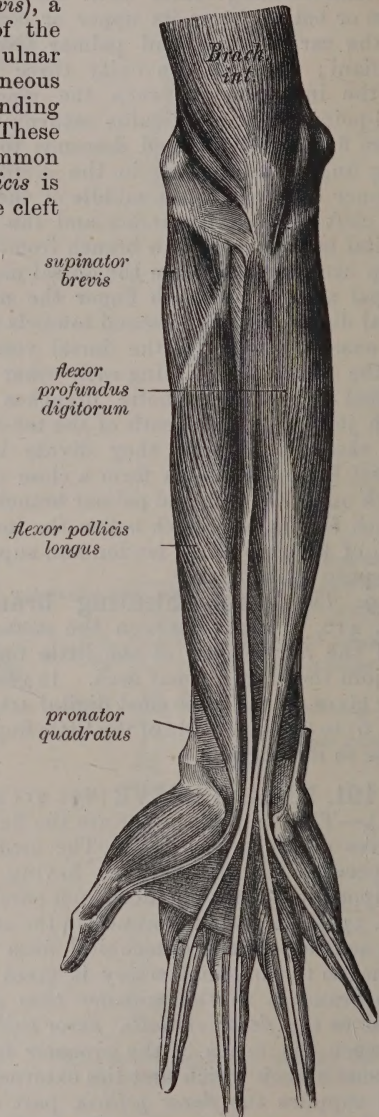


Fig. 414.—Deep muscles of the front of the forearm.

between the index and middle fingers, supplying the second *lumbricalis*, and dividing beneath the artery to supply the opposed surfaces (7, 8 c.) of the fingers;

the last passes to the cleft between the middle and ring fingers, and receives a communicating branch from the ulnar (8 c., and 1 d.).

Upon the extremities of these nerves in the thumb there are about 60 Pacinian corpuscles (fig. 407), upon those in the index finger are 56 on the thumb side and about 40 on the ulnar side, on the middle finger are about 40 on the thumb side and about 35 on the ulnar side. On the articular branches of the digital nerves there are for each joint of each finger from 12 to 25. In all there are usually about 360 such corpuscles on the median nerve.

192. THE ULNAR NERVE, like the median, gives no branches in the arm, and lies at first internal to the brachial artery, but leaves it along with the inferior profunda, and, having pierced the inner intermuscular septum about 14 cm. above the elbow, it descends on the inner head of the triceps to the space between the olecranon and inner epicondyle, grooving the latter (fig. 413). Having passed between the heads of the *flexor carpi ulnaris*, it lies on the *flexor profundus digitorum* and receives the communicating branch from the median, from thence accompanying the ulnar artery on its inner side, and, like it, finally dividing at the wrist into superficial and deep terminal branches.

At the elbow it gives an articular branch, two filaments to the *flexor carpi ulnaris* (8 c., 1 d.), and one to the inner part of the *flexor profundus*. About the lower third of the forearm it gives off a palmar cutaneous (1 d.), which descends on the front of the ulnar artery to the skin of the wrist, and a larger dorsal cutaneous branch which passes beneath the *flexor carpi ulnaris* tendon to the back of the wrist, there supplying the back of the little and ring fingers and half that of the middle (fig. 379). The three superficial terminal branches (1 d.) are distributed (a) to the skin of the hypothenar eminence, to the fourth *lumbricalis* and the *palmaris brevis*, (b) to the ulnar side of the little finger, and (c) to the opposed surfaces of the little and ring fingers. This branch sends off filaments to the skin of the palm, and a communicating branch to the median. The deep branches accompany and overlie the deep artery, and supply articular branches to the carpo-metacarpal joints, except the first and second, and muscular branches to the third *lumbricalis*, to the seven *interossei*, to the two *adductors* and to the *deep flexor* of the thumb.

193. DEEP MUSCLES ON THE FRONT OF THE FOREARM.—**Flexor profundus digitorum** (fig. 414) arises from the front and inner side of the upper two thirds of the ulna, as far as the origin of the *pronator quadratus*, and from the ulnar half of the interosseous membrane. It forms a thick, flat, fleshy mass, divisible into three parts, a middle and two lateral. The outer or index slip is the most separable, and arises as high as the coronoid process, and chiefly from the interosseous membrane; the inner or little finger portion arises from the inner side of the ulna. The muscle ends in a much fasciculated tendon, whose strands unite near the wrist into four cords, one for each finger, that for the index becoming distinct before the others. These lie under the annular ligament and pass to the fingers, at first beneath the tendons of the *flexor sublimis*, then, having passed through the splittings of these tendons, they are inserted into the bases of the third phalanges.

As these tendons pass under the annular ligament they are enveloped in a large loose synovial sac, the great carpal bursa (fig. 406); this extends about 1 cm. above the wrist and downwards about half-way along the metacarpal bones, ending below in a blind pouch around each tendon as it enters its special canal. The cavity of this bursa is usually divided into two by a septum attached to the middle-finger tendon.

In each finger the sheath of the tendon is lined by a proper synovial sheath; these begin blindly above, rarely communicating with the carpal bursa, except in the case of the thumb, whose sheath does often communicate, and in the little finger whose sheath occasionally opens into the cavity of the bursa (fig. 406).

The synovial membrane of the digital sheath enwraps the two tendons at first, and the deep tendon is tied to the bone by one or two flat bands (**retinacula**). Where the tendons pass each other they are generally free, but when the deep tendon has passed through, it is tied to the superficial tendon, now underlying it, by a soft round cord (**vinculum**). Finally, the deep tendon is tied to the distal end of the second phalanx by a flat **retinaculum inferius**.

The anterior interosseous nerve supplies the slip of the *flexor profundus* to the index finger (8 c.), and the lower part of that to the middle. The ulnar nerve (8 c., 1 d.) supplies the rest of the muscle.

The **lumbricales muscles** (fig. 414) arise in the hand in the clefts between the several tendons of the *flexor profundus*. They are four slender, fleshy bundles, the first and second of which are attached to the radial sides of the first and second tendons respectively, passing on the radial side of their respective fingers, and are inserted by tendons into their dorsal aponeuroses (p. 294). The third and fourth arise from the opposed surfaces of the contiguous tendons, and are inserted, like the first and second, into the radial sides of their digits. Each *lumbricalis* passes beneath the digital vessels under the superficial interdigital ligament. The first and second are supplied by the median, the others by the ulnar nerves. The *lumbricales* flex the first phalanges on the metacarpal bones, but they can also assist in maintaining the extension of the interphalangeal joints.

Flexor pollicis longus (fig. 414) arises from the front of the radius below the oblique line and above the *pronator quadratus*, as well as from a small part of the interosseous membrane. It has a supplementary origin by means of a short fusiform belly from the coronoid process, the remains of the obsolete superficial flexor of the pollex. This slip ends in a tendon which as it descends receives the radial fibres, thickening towards the wrist. The tendon passes

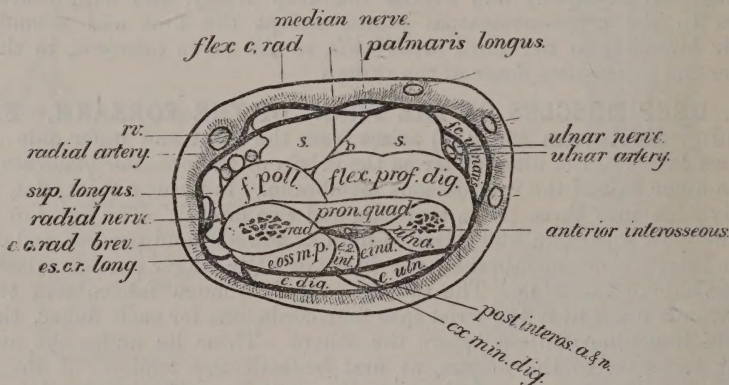


Fig. 415.—Section across the lower sixth of the forearm.

under the annular ligament, then between the two parts of the *flexor pollicis brevis* and between the two sesamoid bones of the thumb. It is inserted into the flexor tubercle of the last phalanx of the thumb. Its nervous supply is from the anterior interosseous. It bears on its surface the *flexor sublimis*, *flexor radialis*, and radial artery.

Dissection.—Separate the tendons of the last pair of muscles and thereby expose the last of this group.

Pronator quadratus (figs. 414, 415).—A small, square, transverse muscle arises tendinously from the oblique line on the lower fourth of the ulna, and by fleshy and tendinous fibres from the space external to this line. It is inserted

fleshy and by tendon into the lower fifth of the front and inner side of the radius between the hinder division of the interosseous edge and the pronator crest. It is supplied by the anterior interosseous nerve and is covered by a strong fascial layer, continuous with the front of the interosseous membrane. The fibres are mostly transverse and parallel, though some are decurrent.

In the sheath overlying it are usually bands of strong vertical fibres from the radius to the carpus, the degenerated remains of a vanished muscle, the *radio-carpeus*, which is rarely muscular.

194. ANTERIOR ANNULAR LIGAMENT.—By removing the superficial lamella of the anterior annular ligament, and the ulnar vessels which underlie it, the much stronger deep layer of the ligament is shown (figs. 399 and 407). This consists of special transverse fibres stretching from the unciform process to the ridge on the trapezium; it arches over the median nerve and nine flexor tendons, four of the *flexor sublimis*, four of the *flexor profundus*, and one of the *flexor pollicis*, enveloped in the great carpal bursa. Its trapezial attachment is split by the tendon of the *flexor carpi radialis*. This ligament is a specialised band of the intermuscular septum between the *palmaris* and the *flexor sublimis* muscles, and herein differs in genesis from the posterior annular ligament, which is derived from the superficial layer of the deep fascia.

Anterior carpal rete (fig. 410).—Beneath the lower edge of the *pronator quadratus*, and upon the front of the wrist is a fine network of vessels, the anterior carpal rete, formed by the anterior carpal branches of the radial and ulnar arteries, by branches of the anterior interosseous and ascending branches of the deep palmar arch, whose arrangement is shown in the figure (fig. 410). When the fingers are being flexed the proximal interphalangeal joint moves first, then the distal, then the metacarpophalangeal. When being extended the metacarpophalangeal move first, then the proximal, and lastly the distal interphalangeal.

195. DISSECTION OF THE MUSCLES OF THE HAND.

—Three sets of short muscles remain to be examined, those of the thumb, those of the little finger and the interossei. Revise and remove the long flexor muscles and clean the surfaces of the short muscles, tracing to them the branches of the deep division of the ulnar nerve and of the deep palmar artery. The deep muscles are most easily separated by dissecting them from insertion to origin.



Fig. 416.—Deep muscles of hand.

A. Muscles of the ball of the thumb.—**Abductor pollicis** (fig. 407), the most superficial, arises from the annular ligament and the tubercle of the trapezium, and is inserted into the outer side of the first phalanx of the thumb. It is supplied by a branch of the median nerve, and is often pierced by the superficialis volæ artery, and often consists of two slips.

Divide this in the middle and thereby exhibit the following:—

Opponens pollicis (fig. 416), arises beneath the last from the annular liga-

ment and the outer side of the trapezium, it is inserted into the whole length of the metacarpal bone of the thumb. It is a more or less bilaminar muscle, and is supplied by a deep branch of the median nerve, which like that to the last usually arises beneath the annular ligament and perforates it to reach its destination.

Flexor brevis pollicis (fig. 416) arises by two heads, a superficial from the trapezium and annular ligament inserted into the outer sesamoid bone, and through it to the outer side of the first phalanx of the thumb, and a deep head from the upper end of the first metacarpal bone from the base of the second metacarpal and the fibrous arch between them. This head is inserted into the inner sesamoid bone. The long flexor tendon passes between these heads.

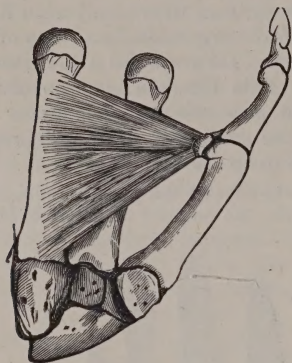


Fig. 417.—Adductor pollicis transversus.

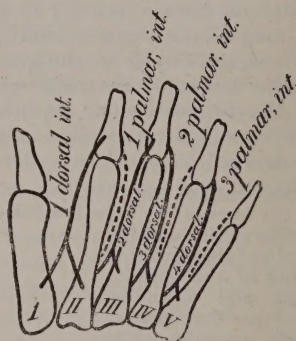


Fig. 418.—Diagram of interossei muscles—The dorsal interossei are represented by black lines, the palmar by dotted lines.!

Adductor pollicis obliquus (fig. 416) arises from the anterior ligaments of the carpus, from the os magnum, and from the head of the third metacarpal; it is inserted into the radial sesamoid bone of the thumb overlying the long flexor tendon. This is often described as a part of the deep head of the flexor brevis. It is supplied by the ulnar nerve.

Adductor pollicis transversus (figs. 407, 416, and 417) arises from the palmar surface of the third metacarpal bone; its fibres pass transversely outwards converging to be inserted into the inner sesamoid bone. This muscle is more or less connected to the last, but is separated by the radial artery dipping through to form the deep palmar arch. It is supplied by the ulnar nerve. These three muscles are imperfectly separable.

B. Muscles of the little finger.—**Abductor minimi digiti** (fig. 407) arises from the pisiform bone and its ligaments, and is inserted into the ulnar side of the base of the first phalanx of the little finger and its dorsal aponeurosis. It is sometimes supplemented by a longer fleshy slip from the fascia over the tendon of the flexor carpi ulnaris.

Flexor brevis minimi digiti (fig. 407, 13) arises from the unciform process, and is inserted into the first phalanx and into a fascial arch over the sheath of the deep flexor tendon. This is separated from the last by the passage between them of the deep branches of the ulnar nerve.

Opponens minimi digiti (fig. 416), seen beneath the last, arises from the unciform process, and is inserted into the fifth metacarpal bone. A detached piso-uncinate slip sometimes runs parallel to its lower border.

The **deep palmar arch** (fig. 410), formed by the union of the deep palmar branch of the radial artery with the communicating branch of the ulnar, crosses the hand transversely beneath the long tendons and on the *interossei*. It

receives the perforating branches from the dorsal rete between the metacarpal bones, sends ascending branches to the anterior carpal rete, muscular branches to the surrounding muscles and descending digital branches, which join the digitals of the superficial arch before their division.

Interossei (fig. 418).—These are arranged in two sets (1) **palmar**, three muscles which adduct the fingers towards the middle line of the middle finger, and (2) **dorsal**, four muscles which abduct the fingers from this line. The palmar *interossei* have each one head. The first arises from the base and front of the second metacarpal bone, and is inserted into the ulnar side of the dorsal aponeurosis of the index finger. The second arises from the fourth metacarpal, and is inserted into the radial side of the dorsal aponeurosis of the ring finger. The third from the fifth metacarpal is inserted into the radial side of the little finger. Each tendon is attached to each of the three phalanges.

The dorsal *interossei* have each two heads arising from the contiguous borders of the metacarpal bones of each interspace. The **first** arises from the upper half of the first and the whole length of the second metacarpal, and is inserted into the radial side of the base of the first phalanx and dorsal aponeurosis of the index finger, it is an *abductor indicis*.

The **second dorsal interosseous** muscle is the *externus medii*, arising from the opposed sides of the second and third metacarpals, and inserted into the thumb side of the middle finger (fig. 419).

The **third**, *internus medii*, arises from the opposed sides of the third and fourth metacarpals, and is inserted into the ulnar side of the middle finger.

The **fourth**, *abductor annularis*, arises from the opposed sides of the fourth and fifth metacarpals, and is inserted into the ulnar side of the ring finger.

The muscles of the thumb are liable to progressive, those of the little finger to retrogressive anomalies.

The student, having removed the remaining muscles adherent to the bones of the upper limb, should read over the descriptions of the bones with the recent specimens before him.



Fig. 419.—Dorsal interossei muscles of middle finger.

THE THORAX.

196. The superficial topography of the thorax (§ 156), which has been examined before the dissection of the pectoral region, should be revised on the removal of the arms, and the shape of the thorax should be examined (§ 83).

Eleven pairs of *intercostal* muscles occupy on each side the spaces between the ribs. These should be cleaned, but without removing the fibrous sheath which covers the muscle between the cartilages of the ribs.

External intercostals (fig. 371, 6).—These arise by short oblique tendons from the sharp outer margin of the subcostal groove of each rib; the fleshy fibres

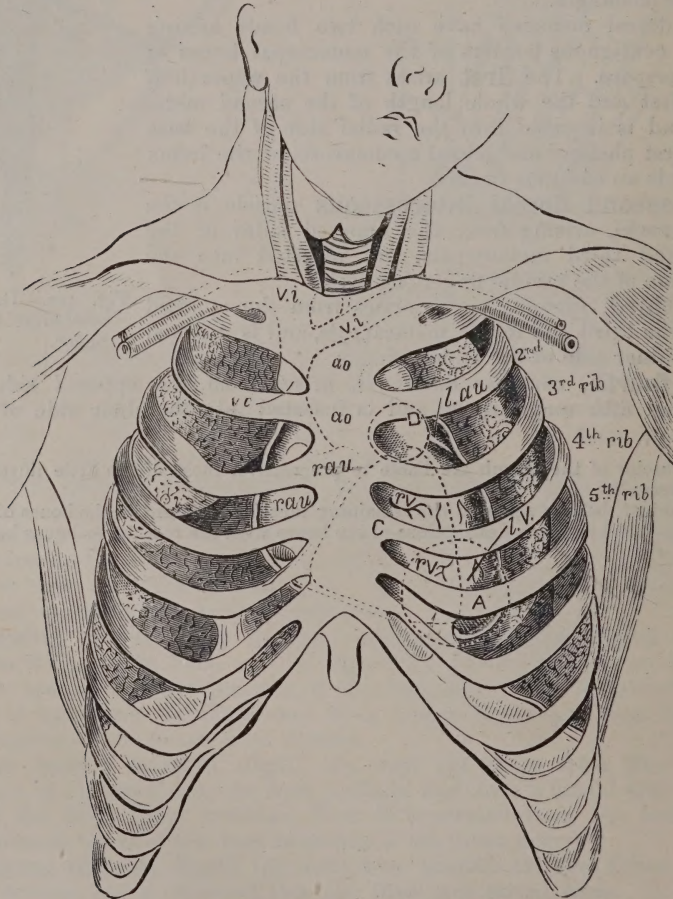


Fig. 420.—Diagram showing the positions of the thoracic viscera.

are attached to these and to their intervals, and descending forwards, are inserted into the upper edge of the rib below, the insertion being mostly by fleshy

fibres. The origins extend backwards to the tubercles of the ribs, and the muscles are thickest behind, where their fibres are most oblique. They become thinner in front, and between the anterior ends of the bony ribs and in the interchondral spaces they gradually degenerate into an **anterior intercostal membrane** of oblique fibres. In the upper six spaces these membranes continue inwards to the sternum. In the lowest interspace the muscle may extend to the tip of the twelfth rib if that bone be short.

Levatores costarum (fig. 360) are strong muscular fasciculi which descend from the transverse processes of the dorsal vertebrae parallel to the hinder edge of the external intercostal muscles, to be inserted into the upper edges of the ribs; the first arising from the seventh cervical transverse process, and the last from the eleventh dorsal. The levatores for the ninth, tenth, and eleventh ribs have additional long fascicles which extend to the next succeeding rib, **levatores costarum longiores**.

Dissection.—Remove the *external intercostals* and the anterior intercostal membrane from the first, second, fourth, sixth, ninth, and eleventh spaces, and clean the surfaces of the *internal intercostal* muscles from the areolar layer which covers them. The intercostal artery (§ 214) and nerve (§ 218) are partly exposed in each space, and should be traced in the fourth and ninth interspaces.

The **internal intercostals** (fig. 421, 4) are weaker, shorter, and less oblique than the externals, especially behind, and arise from the lower and inner edges of the cartilages and ribs as far back as their angles, and descending backwards, are inserted into the upper and inner edges of the ribs below. They are thicker and have longer fibres in front than behind, and are replaced in the spaces internal to the angles of the ribs by a **posterior intercostal membrane**, whose thickened hinder and inner margin forms the superior costo-transverse ligament (fig. 204, 11). In the last two interspaces their anterior border is directly continuous with the internal oblique, to whose fibres they are parallel.

The *intercostals* approximate the ribs. When the first rib is raised and fixed by the *scaleni*, the *external intercostals* elevate the ribs and evert their lower borders, thus enlarging the thorax. The usual actions of the *internal intercostals* have not been definitely determined. While it is probable that under ordinary circumstances the two intercostals co-operate, yet experiment has shown that when the last rib is fixed the *internal intercostals* depress the ribs, and so act as expiratory muscles. From the arrangement of the muscles it is hard to understand why they should not co-operate with their external neighbours, with which they are so closely connected by innervation. On the other hand, if they have the same action it is difficult to understand the persistence of the structural dissimilarity.

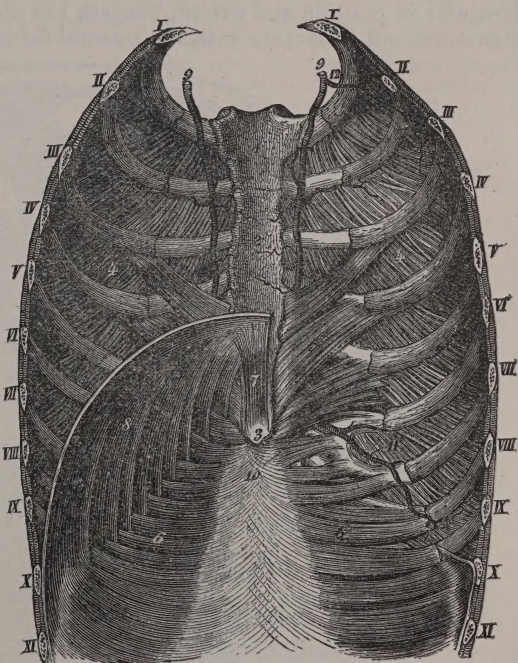


Fig. 421.—Anterior wall of the thorax seen from behind, showing the internal intercostals, triangularis sterni (5), diaphragm (7, 8), and transversalis (6, 6').

In the lumbar region the costal processes (p. 107) are united by intercostal muscles (**anterior intertransversales**). The cervical intercostals are two-fold—(1) short fibres between the costal processes (**anterior intertransversales**, § 490); (2) specially developed portions forming the *scaleni* (§ 490).

Dissection.—Remove on the right side the interchondral portions of the *internal intercostals* from the six upper interspaces, thereby exposing the internal mammary artery (§ 428 and fig. 421, 9) and the *triangularis sterni* muscle (fig. 421, 5). These can be more fully seen by dividing the cartilages of the second to the sixth ribs close to the sternum and close to their junction with the bony ribs, and removing the intermediate pieces.

Remove the *intercostal* muscles from the first and eighth spaces on the right side, and separate with the handle of the scalpel the lining membrane of the thorax which underlies them, from the inner surface of the intervening area of the thoracic wall. Cut across the ribs from the second to the eighth, 5 cm. external to their angles, and cut the cartilages of the seventh and eighth ribs where they join the bony ribs, removing this part of the wall of the thorax. The outside of the pleura thus shown is rough, closely connected to the thin subjacent areolar layer (**endothoracic fascia**) which intervenes between it and the thoracic wall.

Transversus thoracis posterior is shown by raising the pleura from the back wall of the thorax below, and consists of an inner layer of the *internal intercostals* on the subpleural surface of the ribs, extending from the inner surface of some of the lower ribs, particularly the eleventh, to the inner surface of the rib but one above. These fibres form a more or less continuous patch, irregular in position and extent, beneath the pleura, with much tendon in their structure, and co-operate with the *internal intercostals*.



Fig. 422. —Horizontal section through thorax of infant opposite the eighth dorsal intervertebral disc.

Dissection.—Divide the pleura along the right side of the sternum, and along the edges of the first and ninth ribs, and reflect the flap backwards. The cavity of the right pleura is thus exposed.

197. PLEURA.—The pleura is a shut sac of serous membrane (§ 33), whose outer or parietal layer (*p. costalis*) lines the thoracic wall, and its inner or visceral layer (*p. pulmonalis*) is adherent to the surface of the lung, which it renders smooth. The continuity of these layers with each other can be seen in transverse section (fig. 422). The visceral and parietal layers are in apposition and glide upon each other during life, there being no real cavity between them until the collapse of the lung causes the walls to separate.

From the line along which the right pleura has been cut in the dissection, it extends backwards and inwards to the vertebral column (fig. 422, 7), and from thence is reflected on the back of the attached part of the root of the lung. It is continuous over the surface of the lung, dipping into its fissures (*ib.*, 4), and anteriorly extends around the thin edge as far as the front of the root, which it covers, and is from thence continued forwards on the side of the pericardium (*ib.*, 6) to the sternum, where it has been divided. The apex of the pleura passes upwards into the neck as far as the level of the sixth cervical vertebra, a little higher on the right than on the left side.

The interior surface is smooth, moist, and glistening. The right and left pleural cavities are distinct, the membranes touching each other behind the upper third of the sternum, where they form a thoracic “ventral mesentery.”

The superior vena cava (fig. 420, *v.c.*) bulges into the cavity of the right pleura above, and the phrenic nerve (§ 412) descending on its way to the diaphragm, about 1 cm. in front of the root of the lung, shines through the membrane as it overlies the pericardium. By removing the strip of pleura which covers it, its whole course can be seen from the point above which it emerges behind the subclavian and internal mammary veins, and crosses in front of, and internal to, the internal mammary artery, from which it receives a companion artery, the *comes nervi phrenici*. The right phrenic nerve gives off one pericardiac and eight to ten pleural branches. The left is longer, and crosses the aorta and passes round the apex of the heart.

Ligamentum pulmonale.—Below the root of the lung the parietal joins the pulmonic pleura by a fold which stretches from the former on a plane

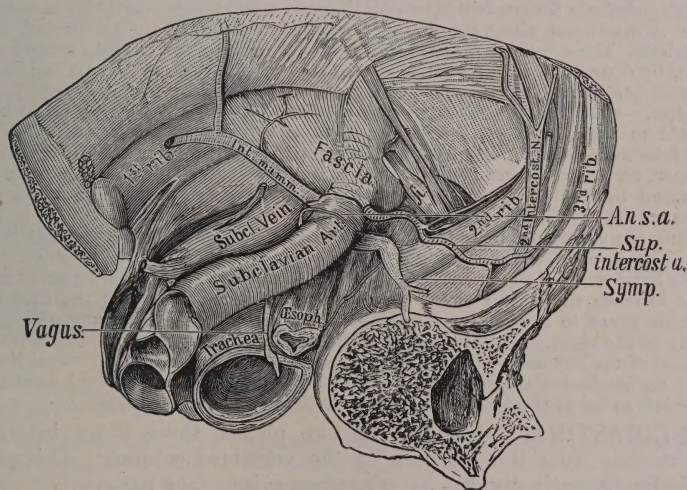


Fig. 423.—View of left side of upper opening of the thorax from below, showing the dome-like upper portion of the endo-thoracic fascia.

behind the pericardium to the hinder edge of the inner surface of the lung, and extends externally from the root of the lung above as far as the diaphragm below, and having a free falciform edge between the lung and the diaphragm. This is seen in horizontal section in fig. 422, in coronal section in fig. 450.

Pleural Sinuses.—The pleura does not descend quite to the costal origins of the diaphragm, nor is the pulmonary pleura co-extensive with the costal and diaphragmatic except during forced inspiration; hence there are marginal sinuses along the lower and front edges of the cavity, where the inner surfaces of folds of the parietal pleura lie on each other. There are three such sinuses:—(1) **Diaphragmato-costal**, along the costal origin of the diaphragm; (2) **pericardio-sternal**, between the pericardium and the sternum (fig. 422, 9); and (3) **mediastino-diaphragmatic**, between the lower margin of the pericardium and the diaphragm.

Along the edge of the second and third of these sinuses and in the vicinity of the phrenic nerve (fig. 424, 19) there are loose folds (*plicæ villosæ*), chiefly of the pleura, which covers the pericardium. These are largest close to the diaphragm, contain masses of fat, and are fringed on their margin with villi (*ib.*, 12). When the pleura requires tapping to evacuate accumulation of fluid, it can be most easily opened in the sixth or seventh interspace, midway between the sternum and the spine.

The endothelial cells of the pulmonic layer of the pleura are thick and polygonal when the lungs are collapsed, flattened during inspiration. On the parietal layer the stomata are numerous on the intercostal spaces, but nearly absent under the ribs. The connective tissue basis is thick in the costal and mediastinal pleura, thinner in the diaphragmatic, thinnest in the pulmonic.

The endo-thoracic fascia, seen by tearing off the costal pleura, becomes stronger towards the top of the cavity, where it forms a strong dome attached to the concave border of the first rib, and to the costal process of the seventh cervical vertebra above the apex of the lung (fig. 423). A few spreading muscular fascicles, segmented from the lowest origin of the *scalenus posticus*, are attached to it. Over the *diaphragm* this fascia is not separable from the sheath of the muscle.

The areolar basis of the pulmonic pleura is continuous with the interlobular tissue of the lung, and through this, at the root of the lung, with the mediastinal areolar tissue, which is connected above with the cervical fascia. This material is rich in elastic tissue, and contains some unstriated fibres at the root of the lung; it is permeated by a wide-meshed network of capillaries derived from the bronchial arteries, and of superficial lymphatics which pass from the sub-endothelial layer to the deeper lymph channels. In the mediastinal tissue there are strong though indefinite fibrous bands, which descend from the prevertebral fascia through the superior mediastinum, along the side of the œsophagus on the right side, and across the aorta on the left. These become diffused in the tissues in front of the roots of the lungs, and can be made, by dissection, to assume the appearance of ligamentous bands, and have been named *suspensory ligaments of the diaphragm*.

Dissection.—Open now the left side of the thorax by dividing the second to the sixth ribs 2 cm. external to their cartilages, and 8 cm. in front of their angles, cut through the first and eighth intercostal spaces, and remove the detached part of the wall. The left pleura appears longer, narrower, descends lower, but does not ascend as high as the right, is more deeply indented by the pericardium internally, and the aorta projects into it above and behind (fig. 422, 21). The left subclavian artery also indents its apex.

By drawing the sternum a little forwards, the right and left **costo-mediastinal sulci** are shown. The level of the former is a line drawn from the right sterno-clavicular joint, almost to the left border of the pre-mesosternal joint, and continued downwards and a little to the right to reach the middle of the sternum opposite the cartilage of the fifth rib, from which it bends again to the left as far as the left side of the metasternum where it turns again sharply to the right. The student should trace these lines on the living thorax.

The bottom of the left costo-mediastinal sulcus corresponds to a nearly vertical line drawn from the left sterno-clavicular joint to the level of the fourth costo-vertebral joint; there it bends to the left as far as the junction of the seventh rib with its cartilage.

198. MEDIASTINA.—Between the two pleuræ there is an intermediate region, stretching from the sternum to the vertebral column. This partition space or mediastinum is divided for convenience into four parts.

1. **Superior mediastinum**, between the presternum in front and the four upper dorsal vertebræ, having the pericardium below and the plane of the upper opening of the thorax above. In this space are the great vessels and the thymus gland, the trachea and œsophagus.

2. **Anterior mediastinum** is the shallow space between the meso- and metasternum in front and the pericardium behind.

3. **Middle mediastinum** is the wide central cavity containing the pulmonary roots, the pericardium and its contents, the phrenic nerve, and the bifurcation of the trachea, intermediate between the last and next spaces.

4. **Posterior mediastinum** is the region between the pericardium in front and the eight lower dorsal vertebræ behind.

All these spaces are laterally bounded by the mediastinal layers of the pleuræ.

Dissection.—Detach the right pleura from the back of the sternum, cut that bone across 3 cm. below its upper edge, and also on the level of the lower edge of the sixth costal cartilage, and vertically divide it between these lines a little to the left of the middle line and remove its right portion without injuring the subjacent parts.

199. THE ANTERIOR MEDIASTINUM thus exposed is small, bounded in front by the left border of the sternum (fig. 424, 2) and the ends of the fourth, fifth, and sixth left costal cartilages, on each side by the pleuræ, and behind by the pericardium (*ib.*, 4); above, it is shut off from the superior mediastinum by the contact of the two pleuræ behind the pre-mesosternal joint; below, it corresponds to the left costo-xiphoid opening in the diaphragm (§ 314). It contains lymphatic glands, sterno-pericardial ligaments, a small portion of the *triangularis sterni*, usually a short part of the left mammary artery, and areolar tissue.

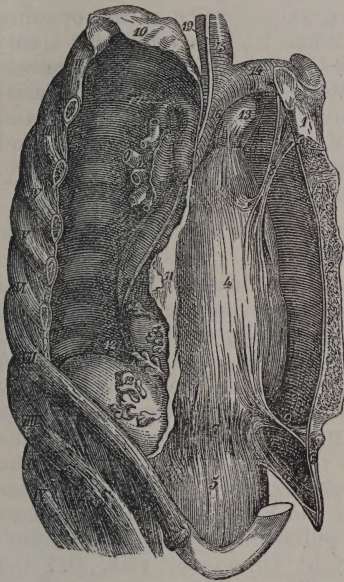


Fig. 424.—Anterior mediastinum and sterno-pericardial ligaments.

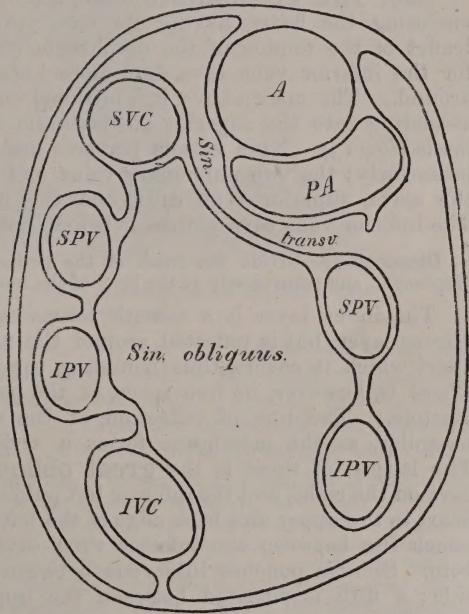


Fig. 425.—Diagrammatic view of the inside of the pericardium, the heart being removed.

These are closely connected with those extra-mediastinal parts, such as the rest of the internal mammary artery and of the *triangularis* muscle which lie between the pleuræ and the costal cartilages, and which can be most easily examined along with the structures in this region.

The lymphatic glands are in two sets. The *parietal* lie along the line of the internal mammary artery (fig. 421, 9), one above each of the upper rib cartilages. Three or four are internal, on the back of the sternum. The lymphatic vessels make a loose plexus, and unite into a large lymph trunk which enters the superior mediastinum. The second or mediastinal series consist of three glands.

united by a plexus of lymphatic vessels on the front of the pericardium. Its ascending lymph trunks join the parietal set.

Triangularis sterni (fig. 421), partly seen before on the right (§ 196), but now easily exposed on the left, arises by a thin fibrous expansion from the lateral margin of the sternum as far up as the cartilage of the third rib, and from the upper edges of the second to the seventh costal cartilages. The lower fibres pass nearly horizontally outwards, the upper ascend nearly vertically, and all, becoming fleshy, are inserted into the lower and inner surfaces of the cartilages of the sixth, fifth, fourth, and third ribs, and into 2 cm. of the bony end of the second rib and the extremity of the first. It separates the internal mammary artery from the pleura, and acts as a depressor of the costal cartilages. It is on the same plane as the *transversalis abdominis* (§ 240).

The **sterno-pericardial ligaments** (fig. 424, 8, 9) are two weak and variable fibrous bands attached to the front of the pericardium (*ib.*, 4), and to the upper and lower parts of the sternum (*ib.*, 1, 3). The superior is strong and sometimes cord-like; the inferior is weak, often double.

Dissection.—Divide these, remove the left half of the sternum, and reflect the pleurae from the sides of the pericardium as far back as the roots of the lungs, leaving the phrenic nerves in place.

200. THE PERICARDIUM (figs. 426, 9; 451) is a somewhat conical sac enclosing the heart, having its base below closely attached to the middle leaflet of the tendon of the diaphragm (fig. 424, 7), especially at the opening for the inferior vena cava, but more loosely attached to the muscular tissue around. The apex above is continued into the sheaths of the great vessels ascending into the superior mediastinum and through these into the cervical fascia (*ib.*, 13). Nine vessels traverse and receive sheaths from it above and posteriorly; the two pulmonary veins and pulmonary artery on each side, and the aorta, superior vena cava, and the obliterated ductus arteriosus above. The inferior vena cava pierces it below, but receives no definite sheath.

Dissection.—Divide the front of the pericardium vertically from the aorta to the diaphragm, and transversely at the level of the roots of the lungs.

The inner layer is a smooth serous membrane, which not only lines the fibrous layer, but is reflected around the several vessels on the surface of the heart which it covers, thus bounding the so-called cavity of the pericardium. There is, however, no free space, as the parietal layer fits close to the heart in diastole. The line of reflection of the serous layer on the heart is very irregular, as the membrane forms a series of pouches between the vessels. The largest of these is the **great oblique sinus** between the inferior vena cava on the right, and the inferior left pulmonary vein, which ascends behind the heart to the upper and back edge of the left auricle (fig. 425). A second smaller pouch lies between the inferior vena cava and the inferior right pulmonary vein. Similar pouches intervene between the pulmonary veins, one on each side; a fifth is situated between the upper right pulmonary vein, and the superior vena cava, at the bottom of which the right pulmonary artery projects. A sixth reflection, the **sinus transversus**, differs in having become perforated at the bottom, and dips between the superior vena cava and the aorta, and from thence passes to the left under the aorta and the pulmonary artery, having the top of the left auricle below. The seventh pouch is that between the left pulmonary artery above and the upper left pulmonary vein below and it is bounded internally by a crescentic fold of the serous membrane, the **vestigial fold**, containing in its free border the remains of the left superior vena cava.

In structure the parietal layer of the pericardium consists of two almost inseparable strata, an outer fascial layer composed of several laminae of mostly longitudinal white and yellow fibres, continuous into the sheaths of the vessels which pierce it, and an inner

representing a serous membrane lined by irregular cells of flattened endothelium with no stomata. The basement layer contains many elastic fibres and fine nerve twigs from the phrenic. The visceral layer, called sometimes *epicardium*, shows on its surface a few stomata; its connective layer is softer, and continuous with the intermuscular connective tissue of the heart; hence this layer cannot be dissected off as a continuous membrane. Fat is often laid down in the deep parts of the tissue. Its surface, especially along the grooves and auricular edge, is closely beset with fine villi, and there is a rich sub-endothelial lymphatic plexus. Its vessels are derived from the mediastinal branches of the internal mammary and from the coronary arteries, with twigs from the œsophageal and phrenic, and its veins chiefly go into the tributaries of the vena azygos. The pericardium is developed as a down-displaced part of the coelom (§ 33). In surgery, when this membrane requires tapping the puncture should be made on the left side in the fourth or fifth interspace, near the sternum.

201. THE HEART.—The heart is a blunt flattened cone, having a large convex surface directed upwards and forwards; a smaller, flatter surface downwards and backwards; a flaccid, thin edge in front and below, and a

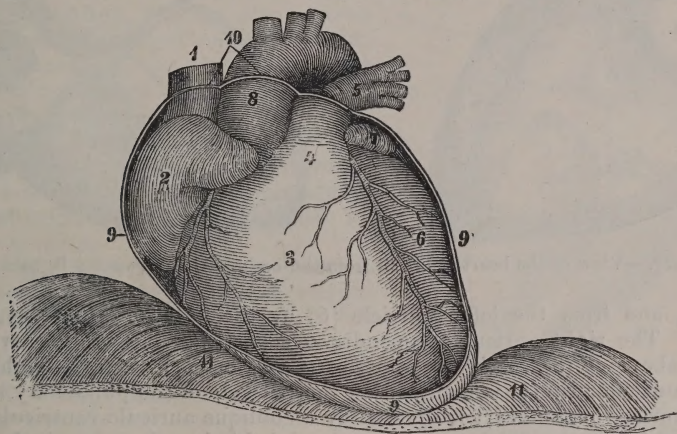


Fig. 426. —View of the front of the heart, as shown when the front wall of the pericardium is removed.

shorter, thick edge behind and to the left. Its apex is directed forwards and to the left, and its base upwards, backwards, and to the right, crossing the sixth, seventh, and eighth dorsal vertebræ obliquely. During life its shape varies, becoming more hemispherical during dilatation or diastole, but its action does not alter its vertical measurement. (For superficial landmarks, see p. 262.)

The heart at birth weighs 25 grammes, and has a volume of 23 c.cm., but in later years its dimensions vary with age, sex, stature, muscular development, and state of health. Measurements of such a flexible organ are apt to vary according to method. Its rate of growth is greatest between birth and the end of the third year, after which it grows more slowly until fourteen, then it increases more rapidly until eighteen, after which the rate of growth diminishes steadily until thirty-five, when the organ attains its maximum size. From this age until fifty there is no appreciable change, but after that period the heart undergoes diminution. Generally speaking, the adult has 5 grammes of heart-weight to the kilo. of body-weight. The female heart averages 5 per cent. less than the male, but is affected also, though to a less degree, by body-weight and stature. These rates are determined by measurements on comparable individuals. Size of heart increases proportionally as the stature of the adult rises from 155 to 170 cm., there being on an average 180 c.cm. for each 100 cm. of height. Above 170 cm. the increase does not seem to proceed at the same rate unless bulk and muscular development keep pace with stature. The volume of the male adult heart averages 270 c.cm., that of the female, 235 c.cm.; the average weight in the male is 230 grammes, in the female, 190; the maximum length of the average male heart is 145 mm.; the maximum breadth, 102; the thickness, 89 mm., and the circumference at base 238 mm. It is the $\frac{1}{130}$ th part of the weight of the infant at birth, the $\frac{1}{140}$ th of the adult man, the $\frac{1}{170}$ th of the adult woman. The axis of the adult heart is inclined at an angle of 40° to the horizon, and of 45° to the median sagittal plane.

Parts seen on opening the pericardium.—The heart consists of four chambers, as has already been noted (§ 49). On the front of the heart (fig. 426 and 427, A) the largest element is the wall of the right ventricle (fig. 426, 3), which tapers upwards to the root of the pulmonary artery (*ib.*, 4), and is separated from the right auricle (2) above by the **auriculo-ventricular**

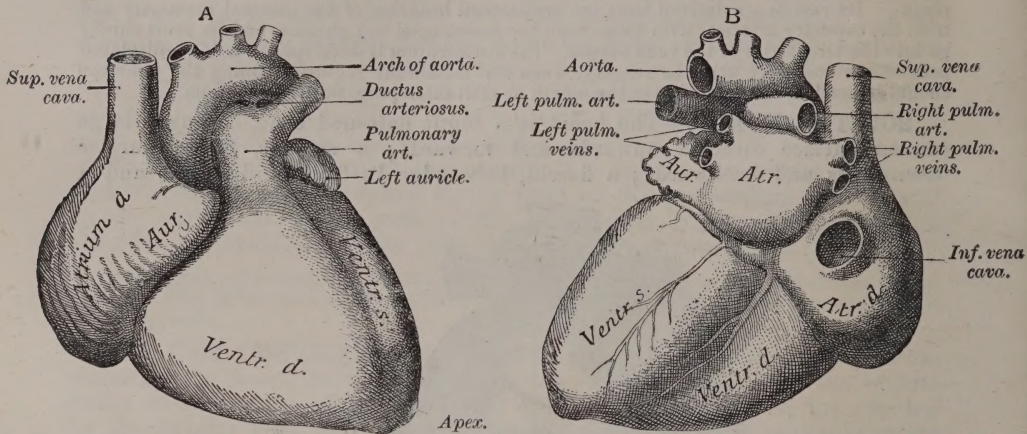


Fig. 427.—View of the heart removed from the body—A, front view; B, back view.

groove, and from the left ventricle (6) by the anterior **interventricular sulcus**. The right auricular appendix overlaps the root of the aorta, which appears above it (8), with the superior vena cava (1) along its right border; the left auricular tip (7) is moulded on the left side of the pulmonary artery.

The surface of the heart is divided by an oblique auriculo-ventricular groove into an auricular or atrial mass above and behind, and a ventricular portion

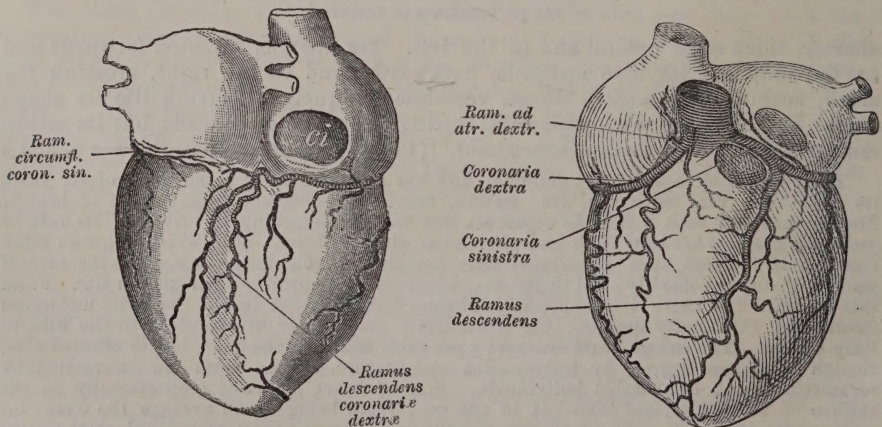


Fig. 428.—Back of the heart, showing the coronary arteries.

Fig. 429.—Front of the heart, showing the coronary arteries.

below and in front. The former is crescentic, embracing the two great arteries in its concavity, the horns of the crescent being the auricular appendices; the latter is conoidal.

Descending from the auriculo-ventricular groove towards the apex are four shallow grooves, an **anterior interventricular** beginning under the left auricular appendix, leftward of the pulmonary artery, and ending to the right of the apex; a **right marginal** a little in front of the thin edge; a **posterior interventricular** on the hinder surface beginning at the opening of the inferior vena cava; and a **left marginal** along the thick edge.

Dissection.—Remove the epicardium and fat along these grooves and the nutrient vessels and nerves of the heart are exposed.

The **right coronary artery** arises from the right side of the aorta immediately above its root, and emerges between the pulmonary artery and the right auricle. It passes to the right in the auriculo-ventricular groove, and sends upwards, close to its origin, a **right auricular branch**, which winds between the aorta and the right auricle, and distributes branches to the aorta, pulmonary artery, the right auricle, and the auricular septum. It gives downwards, 1st, a branch to the front wall of the right ventricle (**preventricular**); 2nd, a **right marginal artery**; and 3rd, a **posterior interventricular**, running in their respective grooves.

The **left coronary** (fig. 429) arises a little higher than the right, and emerges between the pulmonary artery and the left auricle, passing leftward in the auriculo-ventricular groove. As it emerges it gives off a large **anterior interventricular branch**, and farther on a **left marginal**.

The two coronary arteries anastomose by a few superficial branches in the auriculo-ventricular and (occasionally) in the interventricular grooves, but they only communicate by very minute branches in the heart substance. They have a thick inner coat, and their capillaries terminate by becoming confluent and giving rise to wide venous radicles.

The **cardiac veins** (fig. 430) accompany the arteries and have single valves at each confluence. The **anterior interventricular** joins the **left auricular vein** and runs backwards in the auriculo-ventricular groove (*ib.*, 10); and from the junction onwards is called the **coronary vein**, receiving the **left marginal** (9) and **posterior interventricular** (*ib.*, 8). The **right auricular vein** (*ib.*, 7) passes in the auriculo-ventricular groove and is joined by the **preventricular** and **right marginal** veins, joining the coronary trunk close to its termination and having a double valve at its mouth.

A minute **oblique vein** (*ib.*, 1), often represented by an impervious streak, crosses the left auricle from the lower end of the vestigial fold to the coronary vein, which becomes dilated and thickened in coats from the junction onwards. This wider part, or **coronary sinus**, with the oblique and vestigial veins, represent the remains of the left superior vena cava. Two valves mark the transition from the coronary vein to the coronary sinus.

Along each coronary artery run the branching and gangliated coronary nerves (§ 218).

Dissection.—Before the removal of the heart from the body its four cavities are to be examined *in situ*, in the order in which the blood passes through them in circulation.

Draw the heart towards the left side of the thorax and on the convex and somewhat quadrilateral antero-dextral wall of the right auricle is seen a faint, somewhat depressed, line, the **sulcus** or **stria terminalis**, extending from the right of the superior vena cava to the

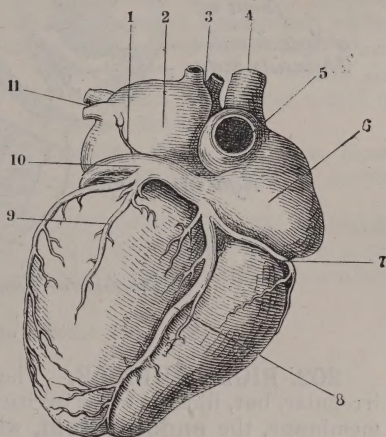


Fig. 430.—Back view of heart, showing coronary veins—2, left auricle; 3, right pulmonary veins; 4, superior vena cava; 5, inferior vena cava; 6, right auricle.

left of the inferior vena cava (§ 53). Open the cavity of the right auricle by making two incisions, one along the right side of the stria terminalis and a second from the mid-point of the first to the extremity of the auricular appendix. As each cavity of the heart is opened it should be washed out with hot water.

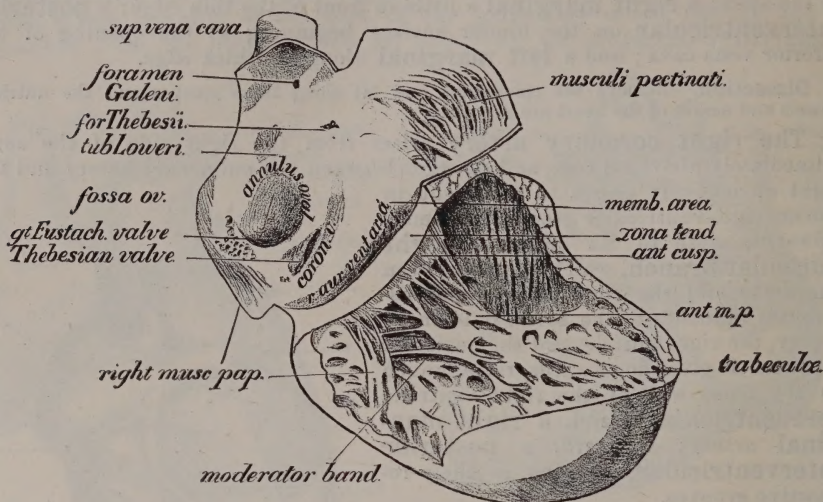


Fig. 431.—Interior of right auricle and right ventricle.

202. RIGHT AURICLE.—The interior of the auricle (figs. 431, 432) appears irregular, but, like the other cavities of the heart, it is lined by a delicate smooth membrane, the **endocardium**, which is the morphological equivalent of the middle and inner coats of the blood-vessels, with which it is continuous. It consists of a layer of endothelium upon a variably laminated connective tissue basis whose deepest layer is continuous with the intermuscular tissue of the heart, and is thick between, and thin over the projecting muscular bundles.

This tissue is rich in elastic fibres, which are fine towards the surface, coarser in the deeper layers and in spots flattened into a fenestrated membrane, especially near the orifices. Some unstriped muscular fibres are embedded in this tissue, and in the right ventricle its deepest layer contains the transitional fibres of Purkinje (§ 41).

Within the cavity of the right auricle the following appearances are to be noted :—

1. The opening of the **superior vena cava** (fig. 431) placed above and to the right and directed a little forwards, the only large cardiac aperture without a valve (fig. 432, 10).

2. The opening of the **inferior vena cava** (fig. 432, 1) is below and to the right, and directed upwards and to the left. The axes of the two caval openings in the adult intersect, forming an angle of 130° , salient forward.

3. The mouth of the **coronary sinus** is situated in the middle line of the body, between the last and the next openings.

4. The **auriculo-ventricular opening** (fig. 431) appears as a smooth funnel-shaped passage, somewhat reniform in lumen, lying below, leftward and in front of the other apertures. Its plane is oblique, with its long axis directed downwards, forwards, and to the right.

5. Scattered over the auricle are about twenty-three minute pits, the **foramina Thebesii**; two-thirds of these are blind, and one-third are the mouths of small veins, of which one, the **right auricular vein**, is constant, and opens on the right of the septal wall below the superior vena cava, the **vena Galeni cordis** (fig. 432, 8).

6. Other appearances claim attention besides the openings. The inferior caval opening is guarded by a crescentic, imperfect, often fenestrated fold, the **Eustachian valve** (fig. 432, 2). This is the persistent right lip of the saccus venosus (§ 53), and lies in the adult obliquely on the front and left side of the orifice, having its concavity directed towards the right shoulder. Its left cornu is continuous on the septum with the left pillar of the annulus ovalis (*ib.*, 6), while its right passes into the tænia terminalis (§ 53; fig. 431). The valve consists of a duplicature of endocardium enclosing a network of muscular fibres, and is strengthened by a slender fibrous thread (**tendo valvulæ Eustachii**) near its margin.

7. The opening of the coronary sinus, originally that of the left superior vena cava, is guarded by the crescentic and often fenestrated **Thebesian valve** (fig. 432, 3), whose attached convexity is below and to the right, and whose free concave margin is directed to the left. It is only a thinned area of the auricular wall isolated by the obliquity of the vein, and consists of a fold of endocardium into which the fibres of the auricle are continued.

Neither of these so-called valves can do more than influence the direction of the blood, especially in fetal life, passing through the orifices; they are incompetent to prevent regurgitation.

8. On the posterior or septal wall is a rounded blind arch, the **annulus ovalis** (fig. 432, 7), which in the fœtus was the inferior margin of the septum superius (§ 53). Its concavity is directed downwards, forming the upper boundary

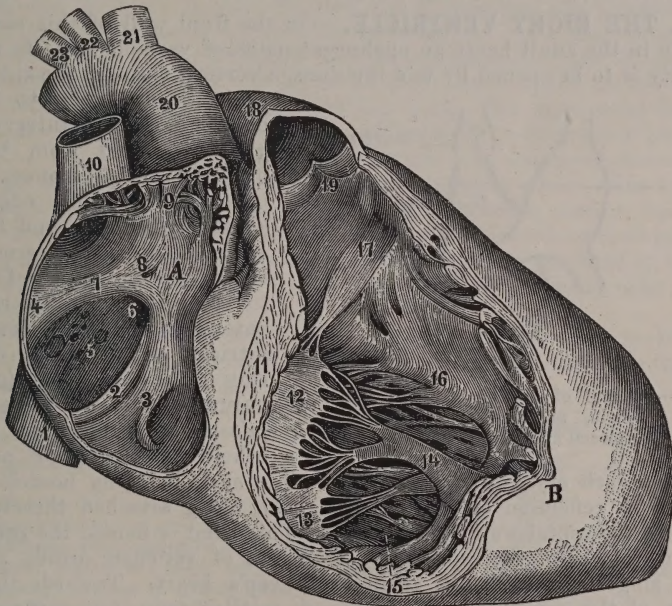


Fig. 432.—Section of right auricle and ventricle, showing the position of the columnæ carneæ—10, superior vena cava; 11, cut edge of ventricle; 12, anterior cusp of tricuspid valve; 13, right cusp; 14, anterior musculus papillaris; 16, septal wall; 18, pulmonary artery; 19, semilunar valves. 20, Aorta; 21, 22, 23, its branches.

of a depressed area, the **fossa ovalis** (fig. 432, 5). The floor of this fossa is the thinnest part of the septum, and is formed of the valvula sinistra, or left wall of the saccus reuniens, and will be better seen when the left auricle is opened. The fossa is about 20 mm. high and 14 broad, and its lower end merges into the wall of the inferior vena cava.

The annulus in the foetus bounded an opening, the *foramen ovale* (fig. 148), which closes at birth by the adhesion of the *valvula sinistra* to the *septum superius*; in 33 hearts out of every 100 an opening remains under the annulus, but this is usually so oblique as to be practically closed.

9. Above the annulus there is a variable convexity, the **tuberculum Loweri**, on the septal wall below the mouth of the superior vena cava, produced by the projection, behind the auricular wall, of a small areolar, often fatty, mass at the margin of the auricular septum, in front and on a plane between the openings of the right pulmonary veins. Continuous with this there is an obscure ridge, the **tænia sagittalis** (fig. 432, 4), marking the margin of the fetal septum spurium (fig. 143, *sp.*) on the inner surface of the front wall below the superior vena cava (p. 84).

10. Along the line of the sulcus terminalis a faintly prominent line appears on the inner surface of the auricular wall, the **tænia terminalis**, marking part of the line of junction of the saccus reuniens and auricular wall.

11. The inner surface of the front wall leftward of the *tænia marginalis* is roughened by a series of parallel muscular bundles with thin-walled interspaces (pilasters or **musculi pectinati**—fig. 431). These are most numerous and somewhat reticulated at the **auricular appendix**, in which the wall is rough and the cavity contracted into a digital pouch.

The cavity of the right auricle, like that of each of the other cardiac cavities, has a capacity of 9 c.cm. at birth, but dilates to 150 c.cm. in the adult, and its wall has an average thickness of 1 mm. The auricles are sometimes called *atria*.

203. THE RIGHT VENTRICLE.—On the front wall of this cavity there is usually in the adult heart an opalescent patch of variable size (*the milk spot*). The cavity is to be opened by two incisions, a vertical through the anterior wall

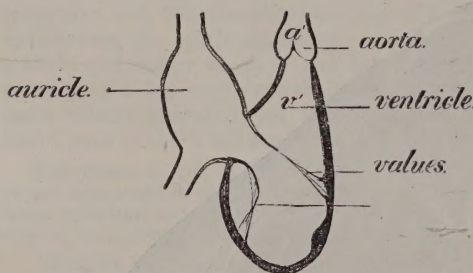


Fig. 433.—Scheme of section through ventricle during diastole, showing open auriculo-ventricular and closed aortic valves.

to be begun 1 cm. to the right of the anterior interventricular groove, carried from below the origin of the pulmonary artery to the right or thin edge, and a second parallel to and below the auriculo-ventricular groove, from the upper end of the former cut to the thin edge. On raising the anterior wall the interior shows an intricate arrangement of projecting muscular bands (**columnæ carneæ**), whereof some are mere *pilasters* or ridges on the wall, others are *trabeculae* or bridges attached at each end and free medially. One such bridging fascicle prevents the complete reflection of the anterior wall, being attached thereto by one end, and to the septal wall by the other. This band is named the **moderator band**; it is frequently represented by a net of reticular bands instead of being a single strong bridge as in the sheep's heart. Towards the margin and apex of the cavity the *trabeculae* are smaller, more numerous, and more closely reticulated.

A third class of fleshy columns, the **musculi papillares** are attached by their bases to the heart wall, and at their other extremity are connected by tendinous cords to the valves guarding the auriculo-ventricular opening. Of the three great musculi papillares in the right ventricle, the largest is *anterior*, attached to the front wall, above and in contact with the moderator band. The second is to the *right* and is also attached to the anterior wall close to the right margin of the cavity; the smallest is attached to the septal wall and is *posterior*.

The cavity of the ventricle is divisible into a **body** below and an **infundibulum** or smoother part which tapers upwards and to the left to the root of the pulmonary artery. The former communicates with the auricle by the auriculo-ventricular opening, whose mouth, as seen from the ventricle, is bordered all round by a continuous down-hanging membranous lip, the **tricuspid valve**, so-called, because its free border is divided by notches into three large flaps, with smaller lobes between. The largest and freest of these flaps is placed *anteriorly*, and a little to the left; a second is on the *right* side of the opening, and the third the widest and shortest and least movable is *posterior* towards the septum. The tripartition of this valve is often very obscure.

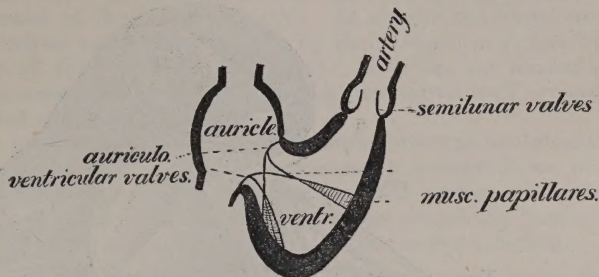


Fig. 434.—Scheme of section through ventricle during systole, showing closed auriculo-ventricular and open aortic valves.

From the anterior musculus papillaris there arise seven or eight **chordæ tendineæ**, each of which divides into two sets of branches, one attached to the opposed margins of the notch between the anterior and right flaps of the valve, and a second or deeper set attached to the ventricular surfaces of the valves between their edges and bases. These cords divide and expand on the backs of the valves after the manner of fan tracery (fig. 448). The right musculus papillaris sends off cords to the borders of the notch between the right and hinder curtain, and the third chiefly to the hinder curtain. To the notch between the anterior and posterior flaps pass many tendinous cords which arise from the septum with a slight or no papillary muscle. The posterior curtain has several tendinous cords attached along its margin, which arise without muscoli papillares from the septum. A third set of short tendinous cords is attached to the deep surfaces of the valves close to their fixed bases; these cords usually arise without papillary muscles.

During ventricular systole this whole membranous lip or valve is driven up towards the auricle by the pressure of the blood within the ventricle (fig. 434), while its margins are drawn downwards by the muscoli papillares, and thus the free flaps are driven into contact, close the opening and prevent regurgitation.

These valves are the remains of the auricular canal (§ 53) around which the ventricle has grown upwards towards the auricle, they therefore consist of two layers. On the auricular surface is a thick layer of endocardium containing a large amount of elastic tissue, and a very few muscular fibres, both radial and circular, continuous from the auricular walls pass into the bases of the valve. Still deeper is a connective tissue layer and the expanded and interlacing tendinous cords of the papillary muscles, covered by a thinner endocardium on their ventricular side. Around the opening is a ring of condensed fibrillar tissue (**zona tendinosa**), to which the base of the valves and the muscular tissue, both of the auricle and ventricle, are attached (§ 53).

In comparing the different openings it is to be noted that the muscular fibres are so related to the aortic and pulmonic orifices that they do not diminish in size when the cavities contract, while the auriculo-ventricular openings are very much diminished during systole, as their musculature is derived from the invaginated ventricular mouth (p. 82).

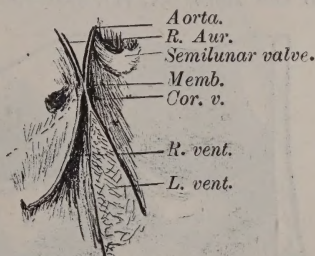


Fig. 435.—The unprotected area of the ventricular septum.

On dividing the tendinous cords of the posterior curtain, the somewhat oval, thin *pars membranacea septi* (figs. 431, 435) is shown behind it, whose upper end extends into the auricle and whose left surface will be found below the hinder right semilunar aortic valve (§ 205).

At the upper end of the infundibulum is the mouth of the pulmonary artery directed obliquely upwards and to the left, and guarded by three **semilunar**

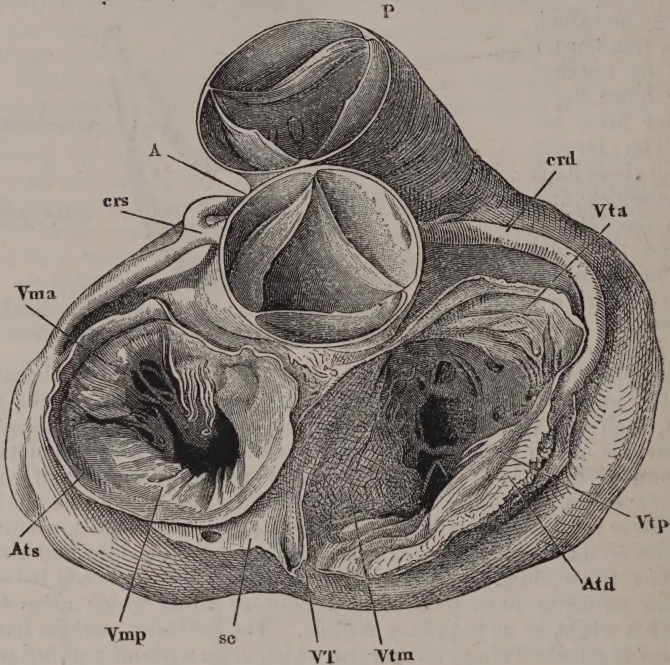


Fig. 436.—Base of heart, showing the relations of the vessels—Vta, Vtm, and Vtp, anterior, median, and posterior cusps of the tricuspid valve; crd, crs, right and left coronary arteries; sc, coronary sinus; Ats, left auricle; Vma, Vmp, mitral valve.

valves, whereof one is *anterior* and to the left (fig. 437, **A**), one posterior and to the *right* (*ib.*, **R**), and the third posterior and to the *left* (**L**).

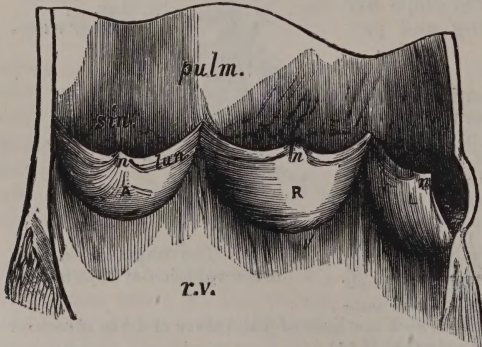


Fig. 437.—Structure of a semilunar valve.

is a fibrous nodule (fig. 437, **n**), the **corpus Arantii**, from which a somewhat crescentic fibrous band passes to the extremity of the attached border of the

Above and behind each valve the wall of the pulmonary artery is dilated into a pouch, or **pulmonary sinus** (*sin.*). Each valve consists of a duplication of endocardium, which on the arterial side becomes assimilated in structure to the inner arterial coats; between these layers is a middle fibrous layer continuous with the fibrous ring which surrounds the orifice. On the arterial side a thin elastic sheet underlies the endocardium. In the middle of the free border is a slightly projecting blunt point, behind which

valve. Between this *tendo valvulae semilunaris* and the free edge of the valve is a weak lunated edge (*lunula*, fig. 437, *lun.*), while many strong radiating fibres pass from the tendo to the convex attached edge of the valve. These valves are pressed peripherally by the blood during ventricular systole (fig. 434), but are forced inwards and downwards, when the ventricle relaxes, by the pressure of the column of blood in the artery, and thus close the opening, their closure producing the second sound of the heart (fig. 433). In closure the three curtains of the semilunar valves meet together, not by their edges only, but by the contiguous portion of their surfaces (fig. 442). Between the auriculo-ventricular and the pulmonic openings is an area on the septal wall crossed by oblique pilasters, called the *fleshy pons*.

Around the arterial opening is a fibrous ring whose lower or ventricular border is rounded, giving attachment to the ventricular muscular fibres, but whose arterial border presents three deep semilunar notches corresponding to the pulmonary sinuses, with three sharp intervening cusps projecting towards the artery, to the edges of which and of the notches the valves are attached.

Dissection.—By dividing the inferior vena cava and raising and drawing forwards the apex of the heart, the smooth back of the left auricle appears (fig. 427), crossed by the oblique vein and separated from the left ventricle by the coronary vein. On each side it receives the two pulmonary veins, and to the left anteriorly is the flattened auricular appendix, longer and narrower than that on the right and lobulated along each margin.

Make an incision from side to side parallel to, and immediately above, the coronary vein, and from each end of this divide the wall upwards to the top of the auricle so as to throw back the posterior wall.

204. THE LEFT AURICLE, internally, exhibits a smooth hinder wall (fig. 438). The right part of the convex anterior wall corresponds to the

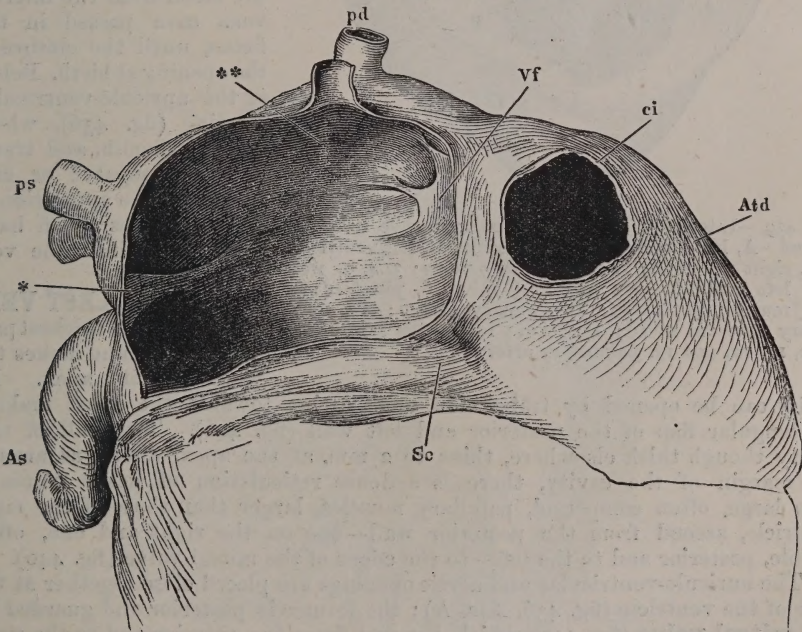


Fig. 438.—Interior of the left auricle seen from behind.

septum, while the left is moulded on the origins of the great arteries. The appendix (*ib.*, *As*) has a narrow opening, and, on being slit open, its walls

show radial pilasters separating the marginal pouches and resembling the larger pectinate pilasters of the right auricle.

The blood enters the left auricle by the four pulmonary veins (ps and pd) which open at the angles of the hinder wall; those on the left are closer

together, a little farther back and on a lower level. There are also four or five Thebesian orifices close to the auriculo-ventricular opening, whereof two at least are constantly venous.

A crescentic marking, like the indentation made by a finger-nail, on the septal wall, with its concavity directed upwards, backwards and to the left, and above the level of the annulus ovalis on the right side (*ib.*, Vt), marks the free edge of the valvula sinistra of the saccus venosus (§ 53). Through the foramen ovale between this and the septum superius the blood from the inferior vena cava passed in the fœtus, until the closure of the opening at birth. Below is the auriculo-ventricular opening (fig. 436), which appears smooth, and transversely elongated or slit-like from the apposition of its two valves which hang downwards into the ventricle.

205. THE LEFT VENTRICLE is the thickest part of the heart and makes the whole of its apex. Its

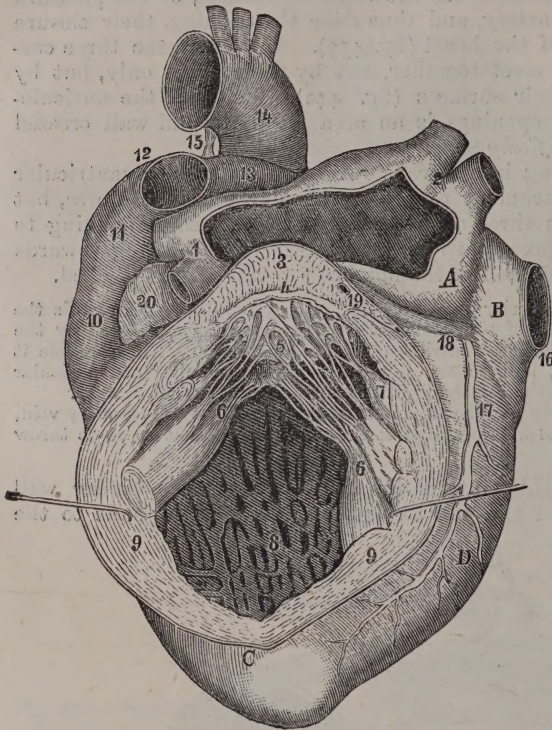


Fig. 439.—Interior of left auricle and ventricle—from behind—A, left auricle; B, right auricle; C, left ventricle; D, right ventricle; 1, 2, pulmonary veins; 3, 4, 9, wall of left ventricle cut; 5, mitral valve; 8, pilasters; 6, 7, musculi papillares; 17, coronary artery; 18, coronary vein cut at 19; 14, aorta; 15, ductus arteriosus; 10, 11, 12, and 13, pulmonary artery.

cavity can be opened by transfixion and cutting towards the apex, making a triangular flap of the posterior and left wall (fig. 440). The wall of this cavity though thick elsewhere, thins to 2 mm. at the apex, where, as around the margin of the cavity, there is a dense reticulation of fleshy columns. Two large, often compound, papillary muscles, larger than those of the right ventricle, ascend from the posterior wall—one on the right and one, often double, posterior and to the left—to the edges of the mitral valve (fig. 440).

The auriculo-ventricular and aortic openings are placed close together at the base of the ventricle (fig. 436, Ats, A); the former is posterior and guarded by the **mitral valve** (fig. 440), which has two flaps, one anterior and to the right (fig. 436, Vtm), and one posterior and to the left (*ib.*, Vtp), with two smaller intermediate lobes. The anterior curtain is the larger and freer, and is smooth on both surfaces as it lies between the two openings, its marginal and medial tendinous cords being approximated. The interval between the curtains has

its long axis directed backwards and to the right side, and at the base of the notch between them at each end of the slit is a small tubercle, *nodi valvulae mitralis, dexter* and *sinister* (fig. 441, Nv).

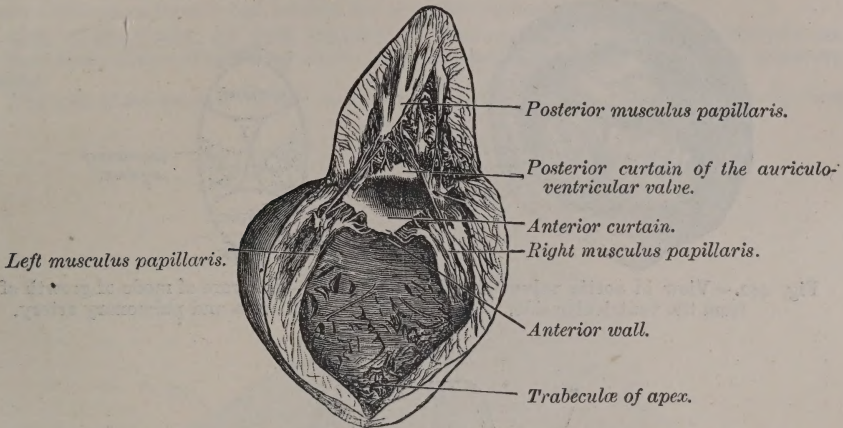


Fig. 440.—Left ventricle, opened from behind, showing mitral valve.

In structure these valves resemble the tricuspid. The bilaminar arrangement of the valve is seen clearly at the base of the anterior curtain (fig. 441, *).

The aortic opening is directed forwards and resembles that of the pulmonary

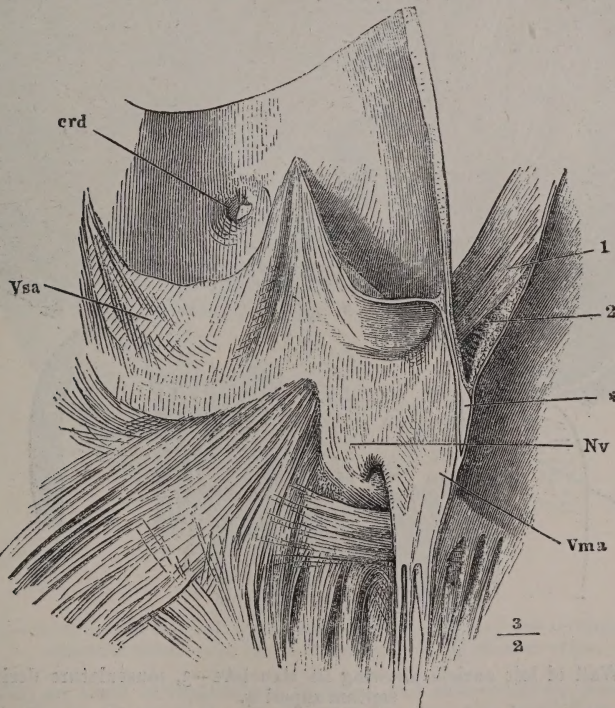


Fig. 441.—Section through the wall of the left ventricle beneath the aorta—*erd*, right coronary artery; *Nv*, nodus valvulae; *Vma*, anterior flap of mitral valve.

artery, having three semilunar valves with dilatations of the aortic wall (**sinuses of Valsalva**) behind them. One valve is behind and to the right, one forward and to the right, the other forward and to the left.



Fig. 442.—View of aortic valves closed, from the ventricular side.



Fig. 443.—Diagram of mode of growth of valves of aorta and pulmonary artery.

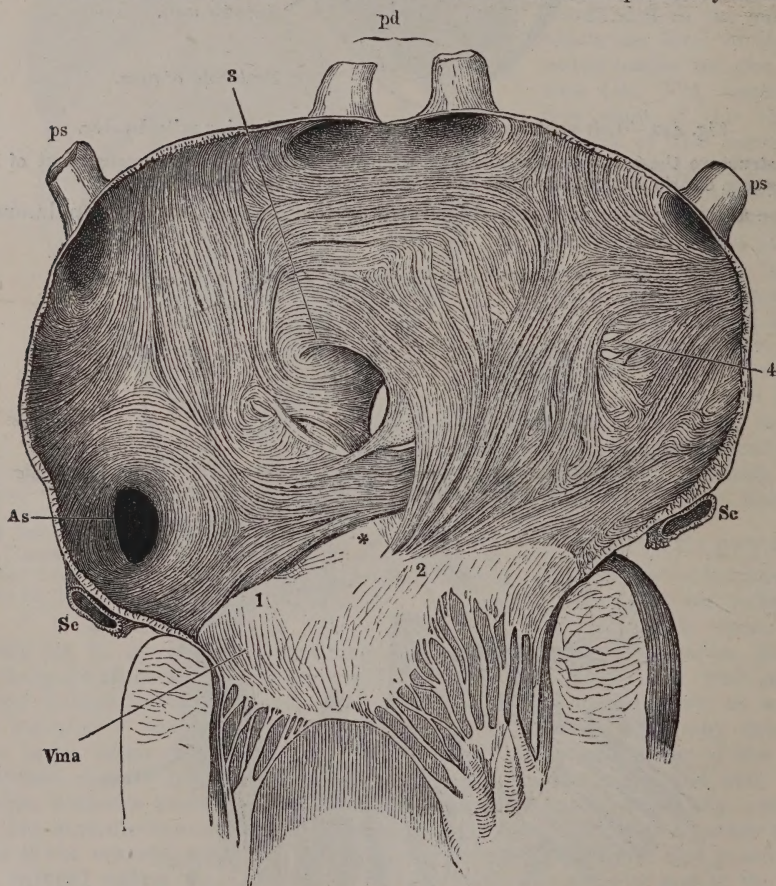


Fig. 444.—Wall of left auricle, showing its structure—3, musculature derived from septum superius.

The arrangements of the curtains of the aortic and pulmonary valves can easily be remembered, as the two openings originally formed the single lumen of the conus arteriosus

with four valves, the two lateral of which become divided by the growth of the septum (p. 83), leaving the odd valves before and behind in the pulmonic and aortic openings respectively (figs. 436, 443). The aortic valves are larger and coarser in structure than the pulmonary valves, and the coronary arteries arise above the two foremost valves. The pars membranacea septi is seen beneath the posterior semilunar valve.

206. STRUCTURE OF THE HEART.—The arrangement of the muscular fascicles can be most easily observed in a heart whose connective tissues have been dissolved by prolonged boiling.

The wall of the heart of the four month's embryo consists of two layers, an outer of fibres

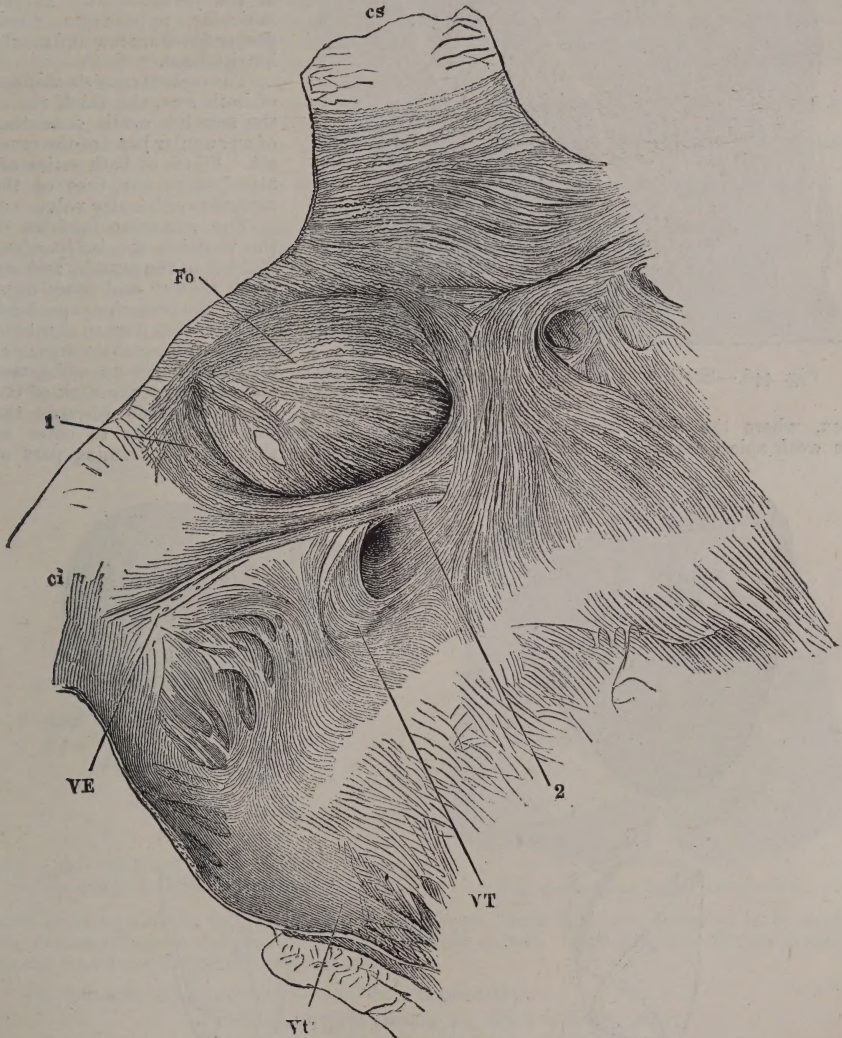


Fig. 445.—Structure of the wall of the right auricle, showing the arrangement of its muscular fibres—Fo, foramen ovale; VT, Thebesian valve.

mostly circular, an inner of longitudinal fascicles, and this condition remains with only slight modification in the auricles. On removing the auricular epicardium the superficial transverse fascicles appear. These are thick on the anterior wall, and pass from auricle to auricle, while on the posterior wall they are somewhat disturbed by the great veins. On

the appendices they become annular. Beneath these are longitudinal fascicles which are attached below to the auriculo-ventricular tendinous zones, and which arch over the cavities,

those of each auricle being nearly independent. Annular prolongations of these striped fibres are traceable along the great veins, extending on the superior vena cava and pulmonary veins beyond the limits of the pericardium. In the auricular appendages these deeper fibres are few and nearly longitudinal.

The septum consists of fibres of both sets, the thick rim of the annulus ovalis consisting of an annular band of the inner set. Fibres of both series are attached to the base of the auriculo-ventricular valve.

The muscular fascicles of the ventricle are independent of those in the auricle, and are much thicker and more complex. The posterior superficial stratum arises from or about the tendinous zone of the auriculo-ventricular opening, and passes obliquely over the back of the heart leftwards towards the

apex, where the fibres turn suddenly backwards and inwards in a *vortex* to enter at the weak apical region into the left ventricle, within which they ascend, forming part of

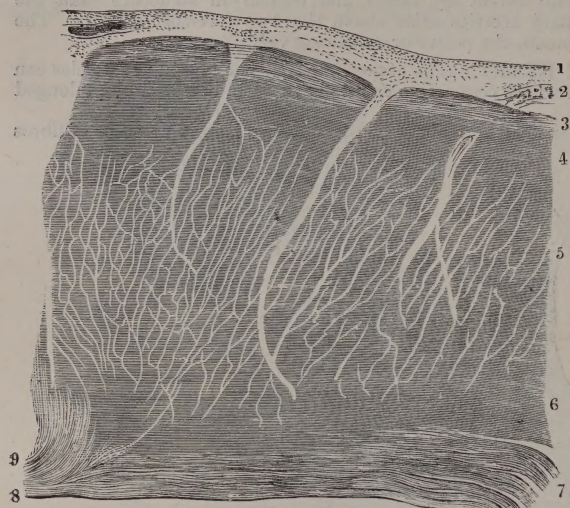


Fig. 446.—Section of left ventricular wall parallel to its long axis.

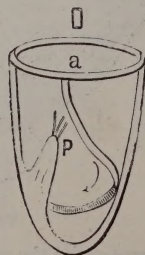
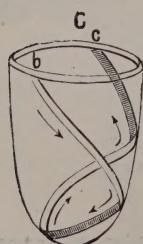
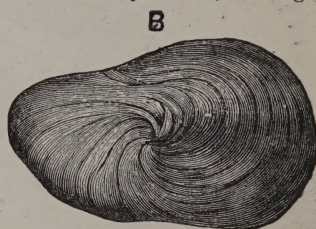
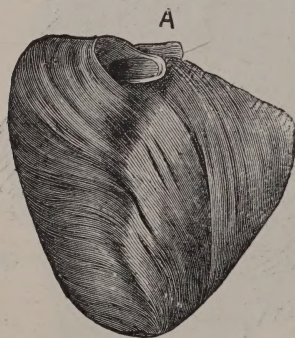


Fig. 447.—Diagram of arrangement of muscular fibres of ventricle—A, seen from behind ; B, vortex seen from below ; C, diagram of the course of muscle bundle to zona tendinosa ; D, diagram of the course of a muscle bundle from the surface layer to the musculus papillaris.

the posterior reticulum of columnæ carneæ and the whole of the right musculus papillaris. The anterior superficial stratum commences in like manner and descends with a similar

obliquity over the front of the heart, the fascicles at the apex and base passing from side to side, but those in the middle being diverted at the anterior interventricular groove, many of them here turning in to the septum, while their places are taken by fascicles with a similar obliquity emerging from the septum along this groove. These, passing to the apex, likewise turn suddenly in a vorticose manner into the interior of the left ventricle, where they ascend, forming the remainder of the trabecular reticulum and the left papillary muscle.

On removing these superficial fibres, the chief thickness of the wall consists of fascicles whose degree of obliquity diminishes from the surface inwards, so that with care they may be artificially separated, according to the skill and fancy of the dissector, into from three to six strata or even more; those fibres nearest the surface run in the same general direction as the superficial stratum, but are less oblique, and at the interventricular grooves they turn into the septum. According to their subsequent destinations these fibres may be divided into five series—

(1) Those which cross in the septum and emerge anteriorly to take part in making up the superficial descending stratum of fibres (fig. 447, D) becoming ultimately continuous with the left papillary muscle of the left ventricle;

(2) Those looped fibres which cross the septum, and ascend to be attached to the left auriculo-ventricular tendinous zone (fig. 447, C);

(3) Those which, crossing in the septum, enter the right ventricle and make the papillary muscles therein;

(4) The figure-of-eight fibres placed nearly on a horizontal plane in the middle region of the ventricular wall; and

(5) The annular fibres which with the last make the most horizontal plane of fibres of the wall. These five sets are not separate layers but interlace in the cardiac wall. The muscoli papillares are not independent of the ventricular wall, but are integral parts of the ordinary parietal musculature, and contract simultaneously with it. From the arrangement of their fibres the auriculo-ventricular openings are contracted during ventricular systole.

The fibrous rings of the aorta and mitral openings are inseparable, and in the angle

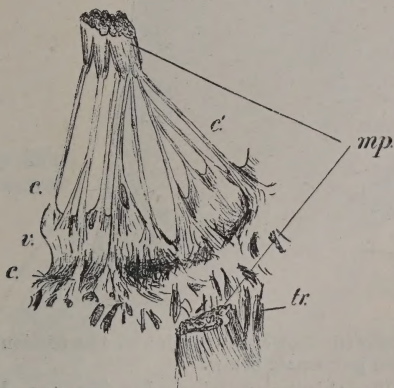


Fig. 448.—Diagram of mitral valve, showing chordae tendineae attached to the mitral valve.

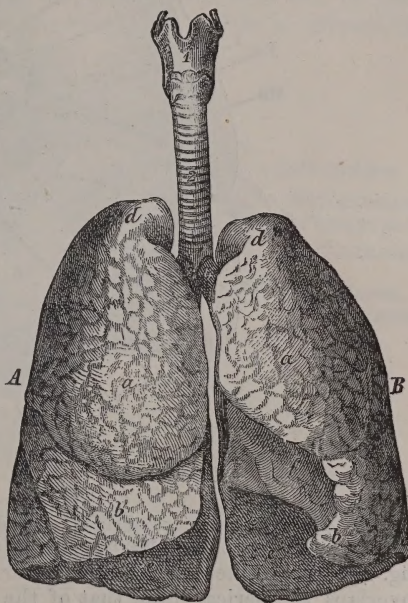


Fig. 449.—The lungs, front view.

between these and the tricuspid openings the fibrous tissue feels very dense, so as to appear like fibro-cartilage as it underlies the *nodus valvulae dextrae*. From this, firm fibrous processes extend round the three contiguous openings.

The following dimensions of the heart are noteworthy:—

Thickness of right auricle, 2.5 mm.; of left, 3 mm.
Thickness of right ventricle, 4 mm.; of left, 1 cm.

	Male.	Female.
Area of right auriculo-ventricular opening in sq. mm.,	127.0	105.0
Area of left auriculo-ventricular opening,	96.0	84.8
Area of pulmonic opening,	68.5	64.5
Area of aortic opening,	70.6	65.2
Proportion of heart-weight to body-weight,	1 : 178	1 : 169

207. LUNGS.—The two lungs are greyish, spongy, elastic organs, varying in colour with vascularity and inflation, darkening with age and city life. They fill during life the whole free cavity of the thorax on each side of the mediastinum, collapsing when the thorax is opened. Each lung has a rounded apex (fig. 449, *d*) rising about 3 cm. above the clavicle; and a concave base (ib., *e*) resting on the diaphragm; its thin sharp margin fitting into the diaphragmato-costal sinus, reaching to the eleventh rib behind, to the ninth in the axillary line on the right, to the tenth on the left; and to the upper edge of the seventh costal cartilage on both sides in the mammillary line. The outer surface is convex, moulded on the inside of the ribs, the inner or mediastinal surface is concave, and into a limited area of it (the root—

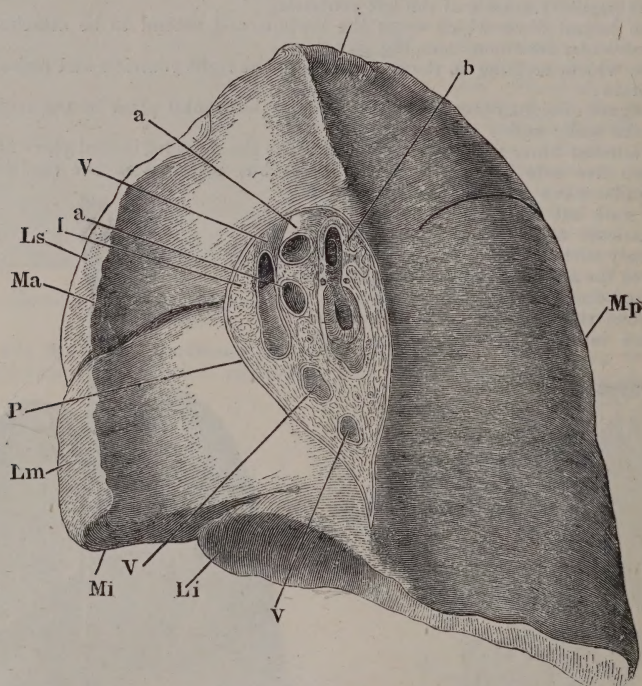


Fig. 450.—Inner surface of right lung, showing the root cut through and the section of the ligamentum latum pulmonale below.

fig. 450) the bronchi and vessels enter. The thin or anterior edge (fig. 450, *Ma*) overlaps the pericardium, that of the left lung is deeply notched by the heart (fig. 449, *f*), and prolonged into a process (*B*, *b*) below and in front. The posterior edge is thicker, and on the left side is moulded on the thoracic aorta (fig. 451).

The right lung (fig. 450) is thicker and shorter, with a higher and more concave base than the left; it is notched on its mediastinal surface by the superior vena cava and occasionally by the inferior. The left is deeply excavated on its mediastinal surface by the heart, and its apex is grooved by the left subclavian artery, and does not rise as high as that of the right.

The lungs form $\frac{1}{37}$ of the weight of the body in the male, $\frac{1}{42}$ in the female; and have a specific gravity of 0.7, and an absolute weight of 1,270 grammes in the male, 1,030 in the female. The right is to the left in weight as 11.2 : 10. The cubic dimensions of the lungs vary at the different periods of respiration; in the extreme of forced inspiration the lungs of an adult man of medium height (1.73 m.) have a bulk of about 7,000 c.cm.; in the extreme

of expiration of 2500 c.cm., i.e., 4,500 c.cm. less. This amount due to the bulk of air expired is called the *vital capacity* of the thorax, and diminishes with stature below and above this standard usually. It is proportionally less in the female. The amount of air which ebbs and flows in ordinary respiration is called *tidal* air, and amounts to about 350 c.cm. The amount in excess of this which can be taken in by a forced inspiration is called *complemental* air, and amounts to about 2,750 c.cm. The amount which can be expelled by force after an ordinary expiration is about 1,400 c.cm., and is called *supplemental* air; and about 2,000 c.cm. cannot be expelled by any force. This is named *residual* air.

Each lung is divided into upper (fig. 449, *a*) and lower lobes (*ib.*, *c*) by the **great fissure** which begins behind and below the apex (6 cm. on the left, 8 on the right, opposite the third dorsal on the left and the fourth on the right), and descends forwards in a spiral line to reach the thin edge in front, opposite the sixth costal cartilage on the left, opposite the end of the seventh rib on the right, crossing the anterior axillary line at the fifth rib. The upper lobe on the right side is again subdivided by a secondary fissure, which arises from the primary opposite the sixth rib at the posterior axillary line, and passes to the thin edge at the fourth rib-cartilage, cutting off a middle lobe (*ib.*, *b*). There is but one fissure in the left lung.

The surface of each lung is mapped into polygonal spaces from 6 to 10 mm. in diameter, the bases of the lobules. In the adult each lobule is isolated by a dark line of carbonaceous deposition.

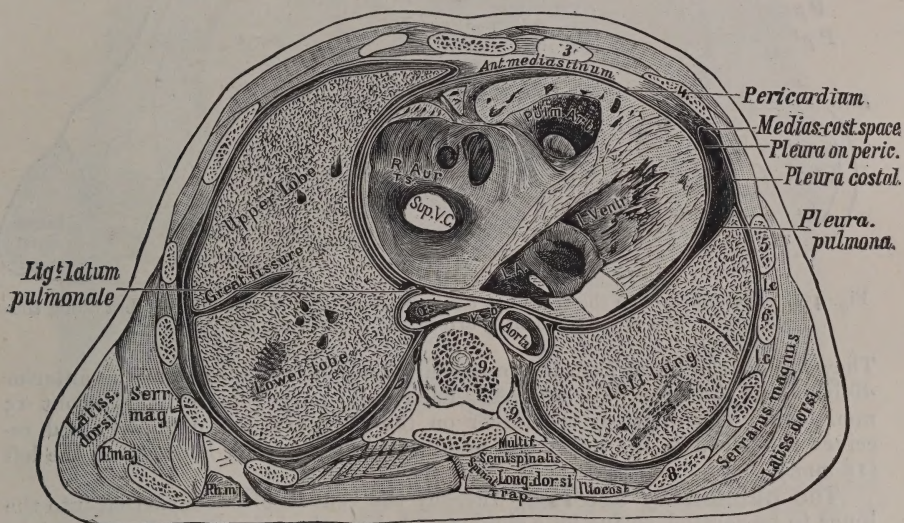


Fig. 451.—Section of the thorax of a boy of sixteen, taken obliquely through the ninth dorsal vertebra, seen from below. The eighth, seventh, sixth, fifth, fourth, and third ribs are seen cut on the right side, while the inferior angle of the scapula is also visible. The ligamentum pulmonale is cut through.

The **root** of each lung is the only place at which it is attached, and is bounded below by the **ligamentum pulmonale**, a fold of pleura whose development is due to the upward traction of the vessels, and the downward growth of the lung in development. The **vena azygos** arches over the right root, the **aorta** over the left; behind the right root is the posterior pulmonary plexus of the **vagus** nerve and the **vena azygos**; behind the left is the descending **aorta** and the posterior pulmonary plexus of the **vagus**. In front of each root is the anterior pulmonary branch of the **vagus**, and still farther

forward the phrenic nerve. The superior vena cava also lies in front of the right root.

The pleura should be removed from the front of the root of the right lung and the anterior pulmonary nerves traced. The vessels in the root are from before backwards and from below upwards—1st, the *pulmonary veins* (fig. 450, V, V, V); 2nd, the *pulmonary artery* (a); 3rd, the *bronchus* (b).

The two **pulmonary veins** which return the arterialised blood from the lung to the left auricle have been already seen at their ending in the left auricle (fig. 428). Traced from thence they pierce and carry off an expansion from the pericardium, and pass nearly horizontally backwards and outwards into the root of the lung, where they are separated from each other by an anterior descending branch of the bronchus: they divide at first dichotomously, but afterwards in an irregular and often plexiform manner. The branches do not accompany the arteries or air tubes, but lie rather superficial to both.

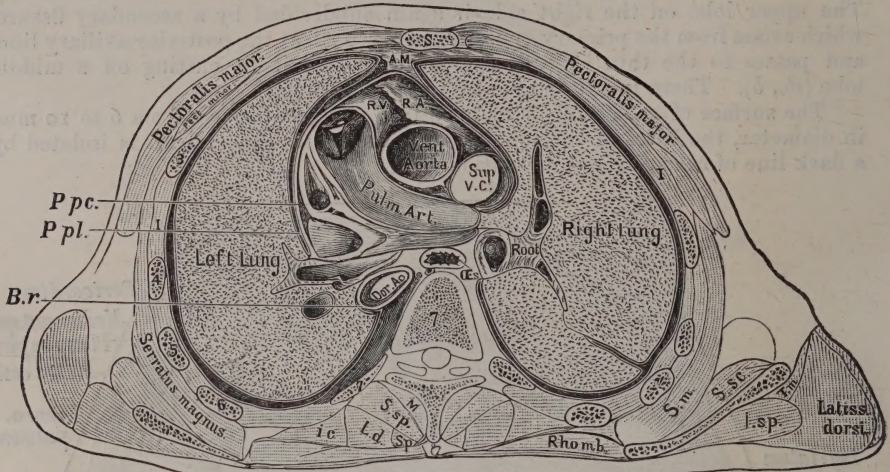


Fig. 452.—Section through the thorax at the uppermost edge of seventh vertebra along the line of the pulmonary artery and roots of the lungs.

They receive the blood from the pulmonary arteries, and also from the anterior divisions of the bronchial arteries. Each pulmonary vein trunk is about 15 mm. long. The upper is the larger on the right (15 mm. diameter), and receives the blood of the upper and middle lobes; the lower is larger on the left (15 mm.).

The **pulmonary arteries**, whereby the venous blood is carried into the lungs to be aerated, spring by a single trunk from the infundibulum of the right ventricle. This lies for its whole extent within the pericardium, a serous sheath of which ties it to the aorta. It is the foremost of the great cardiac vessels, and arises between the auricular appendages; from thence it arches backwards, and a little upwards and to the left, its concavity embracing the front and left side of the aorta, and its convexity being separated by the pericardium from the left lung. Having reached the level of the sixth dorsal vertebra on a plane behind the ascending aorta, and in front and below the bifurcation of the trachea, it divides into its right and left branches which diverge from each other at an angle of 135° , and which, piercing the pericardium on each side, pass nearly horizontally to the roots of their respective lungs. The pulmonary artery is about 5.3 cm. long, about 29 mm. in diameter, and its sectional area is to that of the four pulmonary veins as 100:99.

On each side of it the cardiac nerves stream downwards to the auriculo-ventricular groove. From the root of its left branch, as it leaves the pericardium, a fibrous cord, 5 to 9-mm. long (the obliterated remains of the foetal **ductus arteriosus**), passes upwards and backwards, to be attached to the concavity of the aorta at the left end of the arch. This sometimes shows an irregular, persistent trace of its original lumen.

The **right pulmonary artery**, larger and wider than the left (21 : 19), passes behind the ascending aorta and beneath the arch, from which it is separated by the branches of the right deep cardiac nerves. In the root of the right lung it lies *below* and in front of the right bronchus, and divides into a large upper and a small lower branch; the former divides again into two,

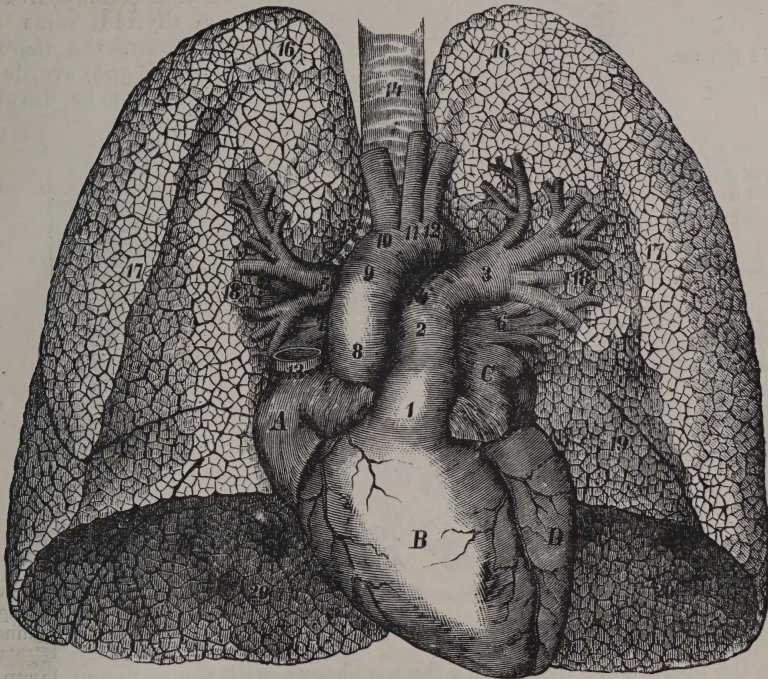


Fig. 453.—Front of the lungs, showing the great vessels—1, root of pulmonary artery; 2, trunk; 3, left pulmonary artery; 4, ductus arteriosus; 5, right pulmonary artery; 6, left pulmonary veins; 7, right pulmonary veins; 8, 9, 10, 11, 12, aorta and its branches; 13, superior vena cava; 14, trachea; 15, right bronchus; 16, apices of lungs; 17, anterior edge; 18, root of lung; 19, inferior lobe; 20, base of lung.

which supply the upper and middle lobes; the latter enters the lower lobe. From these by successive divisions, which correspond to the divisions of the bronchi, the branches for the smaller lobules arise, each of which is an end-artery and does not anastomose with its neighbours. Besides the lobular branches there arise fine bronchial branches, which supply the bronchial tubes and anastomose with the capillaries of the bronchial arteries.

The **left pulmonary artery** passes in front of the descending aorta *above* the left bronchus, and divides into an upper smaller and a lower larger branch.

208. TRACHEA AND BRONCHI.—The bronchial tubes, whereby air is conveyed into the lungs to aerate the blood, are the subdivisions of the **trachea**, which begins at the lower border of the fifth cervical vertebra, as the con-

tinuation of the larynx (§ 498), and extends downwards for 11 cm., nearly in the middle line ending opposite the lower border of the fourth dorsal (third in the infant), by dividing into right and left bronchi. It lies partly in the neck and partly in the thorax, the cervical portion varying from 1 to 5 cm. in length, according to the position of the head. In this region it is movable and surrounded by a laminated sheath of elastic areolar tissue, which is covered by skin, fascia, the *sterno-hyoid* and *sterno-thyroid* muscles, and the median extension of their fascial sheath which covers the narrow lozenge-shaped interval between these muscles. Beneath these coverings the second and third rings are crossed by the isthmus of the thyroid body, below which is the spot at which the windpipe is opened in the operation of tracheotomy.

In the tracheotomy area the inferior thyroid veins and, when present, the *thyroidea ima* artery (§ 506) overlie the tube, and must be drawn a-

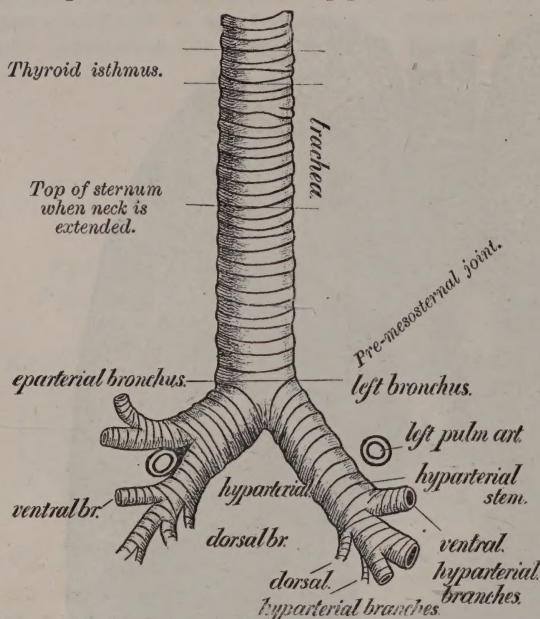


Fig. 454.—Trachea and bronchi schematically drawn.

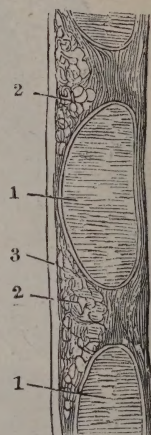


Fig. 455.—Enlarged view of section through three rings of trachea (1); 2, glands; 3, mucosa.

side in the operation. Behind lies the œsophagus, with the recurrent laryngeal nerves ascending on each side in the angles between the two tubes. On each side are the lateral lobes of the thyroid body and the carotid arteries.

The trachea enters the thorax through the inlet, and descends in the superior mediastinum behind the *arteria innominata*, in front of which the *left vena innominata* lies. Immediately above its bifurcation it is crossed by the aortic arch, from which it is separated by the deep cardiac nerves. Behind, and projecting to its left side below, is the œsophagus, which is closely tied to it, and which, together with the aorta, left vagus, left recurrent veins, and left subclavian artery, intervene between it and the left pleura. The left carotid crosses it in front and to the left; and on the right lie the superior vena cava, right vagus, and a large lymphatic gland, behind which the pleura is reflected on it (fig. 423).

In shape it is cylindroidal, flattened behind, its transverse diameter averaging 21 mm. in males, 18 in females. In the fetus it is much flatter, but gradually rounds after birth.

The trachea consists of the following layers:—

(1) Externally, a fibrous coat, in which are embedded the 16-18 C-shaped rings of hyaline cartilage, which keep it open. Each of these is two-thirds of a circle (fig. 455, 1), and about

3 mm. in vertical height, somewhat D-shaped in vertical section, flat outside, and convex towards the lumen of the tube; posteriorly each ring ends in rounded ends. The first ring is the broadest; the intermediate rings may bifurcate or unite; the penultimate is broader in the middle than at either end; and the last has in the middle a descending recurved spur which passes below and in front of the bifurcation (fig. 457, 4).

The fibrous membrane wherein the rings are embedded (fig. 455, 2) is of white fibrous and elastic tissue, the latter abounding especially in the interspaces, and it completes the tube behind where the rings are deficient. Here its tissue thickens, but becomes looser in texture, and on its inner surface is a continuous stratum of unstriped muscle (*trachealis*),

whose fibres are chiefly transverse, with a few superadded external longitudinal fibres. Upon the outer surface of these is a fine gangliated plexus of non-medullated nerves.

(2) An areolar layer rich in adenoid tissue, uniting it somewhat loosely to

(3) A submucous layer, mostly of longitudinal elastic fibres, in which are embedded the mucous glands and sometimes a little fat.

(4) The mucous membrane is smooth and pinkish, though usually not very vascular, its epithelium consists of a layer of ciliated columnar cells (fig. 456, *b*), elongated and irregular at their bases, which are surrounded by a stratum of smaller irregular cells (Debové's layer—*ib.*, *c*), some of which

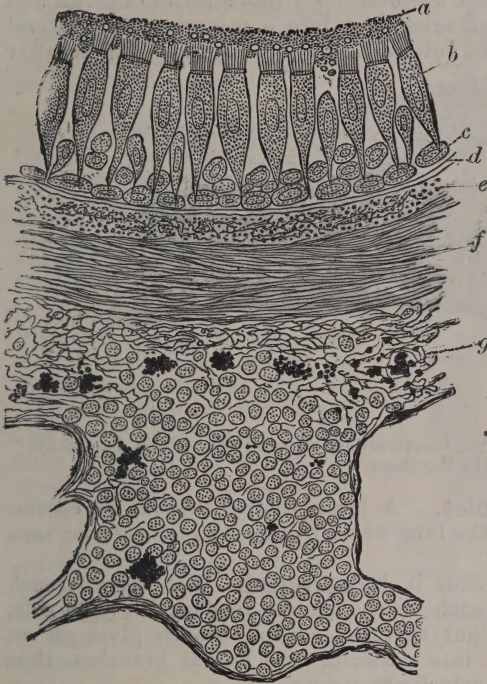


Fig. 456.—Section of wall of a bronchus—*a*, consolidated mucus; *c*, elastic fibres divided transversely, forming the inner fibrous layer; *f*, bronchial muscle; *g*, outer fibrous layer with leucocytes and black pigment flecks, upon a mass of adenoid tissue rich in leucocytes.

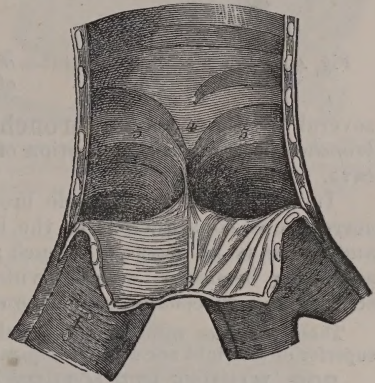


Fig. 457.—Bifurcation of trachea opened from behind.

reach the surface, and being muciparous may become goblet cells. These are placed on a thick homogeneous basement (*d*) pierced by a few processes from the connective cells of the subjacent areolar layer which is rich in lymphoid tissue, and closely connected to the submucous layer. Mucous glands are numerous and large posteriorly, smaller glands lie also along the borders of the cartilage rings.

The vessels of the trachea are derived from the inferior thyroid, and run downwards longitudinally, forming a polyhedral capillary plexus. The nerves are derived from the vagus and its recurrent branch.

The **bronchial tubes** diverge at an angle of 100° , the **right** being more nearly horizontal, 60° from the perpendicular, while the **left** diverges at an angle of 40° . On looking down into the trachea the ridge of separation of the two bronchi appears sharp, and projects a little to the left of the middle line; hence, foreign bodies entering the trachea tend to fall into the right bronchus. In structure the bronchi resemble the trachea; the right contains 6-8 rings, the left 9-12.

As the left bronchus passes over the œsophagus and descending anteriorly it gives origin posteriorly to a few longitudinal muscular fibres which are lost on the œsophagus, and are sometimes described as the **broncho-œsophageus muscle**.

The right bronchus passes behind the superior vena cava, and on reaching the root of the lung gives off an **eparterial branch** which passes above the level of the pulmonary artery and is distributed to the upper lobe. The main stem then passes behind the pulmonary artery which grooves it and divides into two **hyarterial branches**, the upper to the middle lobe, the lower to the lower lobe. Each of these divides dichotomously into a series of *dorsal* and *ventral* branches, each of the former subdivides into a posterior and a lateral branch, and each of the latter into an anterior and a lateral; each of these, after

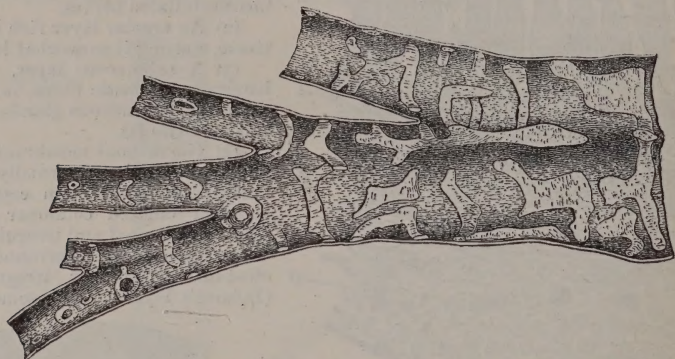


Fig. 458.—View of bronchial tubes of the fourth order, showing the patchy disposition of the cartilage.

several divisions, become **bronchioles**. A large ventral *azygous* or *cardiac* bronchus passes into that portion of the lung which lies close to the inferior vena cava.

In the left lung the whole bronchus is **hyarterial**. The upper branch corresponds consequently to the branch to the middle lobe on the right side, and there is no azygous branch; but the first ventral branch gives off an ascending bronchus, which divides into posterior and lateral branches, thus serving as a succedaneum for the eparterial bronchus.

These branches seem to indicate that the left lung has no lobe corresponding to the superior of the right nor a part comparable to that supplied by the azygous bronchus.

209. MINUTE STRUCTURE OF THE LUNG.—

In the secondary branches the walls alter in structure. The cartilages cease to be in regular rings and become irregular patches, and the muscular fibres form complete circles in the walls of the tubes (fig. 458). When the branches become 1 mm. in diameter they lose all trace of cartilage and of glands, and the wall of each presents irregular dilatations. These begin as a series of small irregular pouches on one side of the tube, but they progressively enlarge, ultimately surrounding the tube, which expands to about 3 mm. in diameter, and ends as a sacculated alveolar

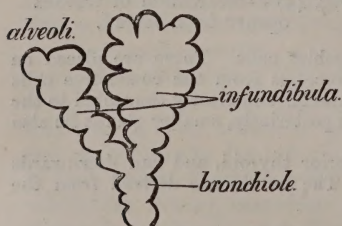


Fig. 459.—Scheme of the termination of a bronchiole.

passage, whose wall and fundus consist of blind pouches, the air cells or **alveoli**. Each of these endings is called an **infundibulum**. In the infundibula the muscular coat disappears, the longitudinal elastic fibres break up into an interlacement around the mouths of the air cells (fig. 460, e), and are connected with

the elastic interlobular and interalveolar tissue, and the columnar epithelium becomes changed into thin pavement cells without cilia, between which are small polygonal granular cells in little clusters of two or three (fig. 463, *d*), and pseudostomata between them. These cells lie on a thin basement of connective tissue in which are amœboid cells which often carry carbon and other solid particles.

In the fœtus the air cells are lined with small granular cells which transform on inflation, and never resume their former shapes. After the lungs have been once inflated, the air cannot be pressed out, and they consequently float in water, a test frequently used in Medico-legal investigations.

Around the air cells in the inter-alveolar tissue there are a few smooth muscle fibres and loose areolar tissue. The air cells are polygonal, and vary in size at different ages. In the lung of an infant of a week old they average $\cdot 05$ mm. in diameter, in a boy of fifteen they are $\cdot 17$ mm., in a man of thirty about $0\cdot 22$ when collapsed. There are about 355,000,000 alveoli in a human lung, having an area of 90 square metres of wall. The branches of the pulmonary artery accompany the air tubes until they become 1 mm. in diameter, when they divide more frequently than the tubes. The minutest arterioles ramify between the alveoli, ending on their walls in a fine-meshed capillary plexus which lies in a single layer in the ridges between the air cells. The vessels are covered by epithelium on both surfaces, and hence project into the air cells on each side (fig. 461).

Entering the root of each lung are **bronchial arteries**, one or two on either side (p. 347). These accompany the air tubes, and their branches go partly to the lymphatic glands, partly to the interlobular areolar tissue, and also to the walls of the bronchial tubes and their branches, in the muscular coat of which they form a capillary plexus with

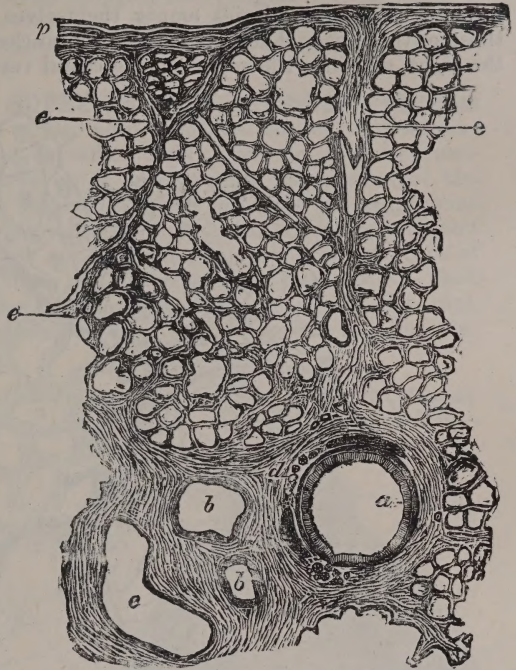


Fig. 460.—Section of substance of the lung magnified, showing bronchiole, the small branches of pulmonary vessels, and the parenchyma around the air-cells.

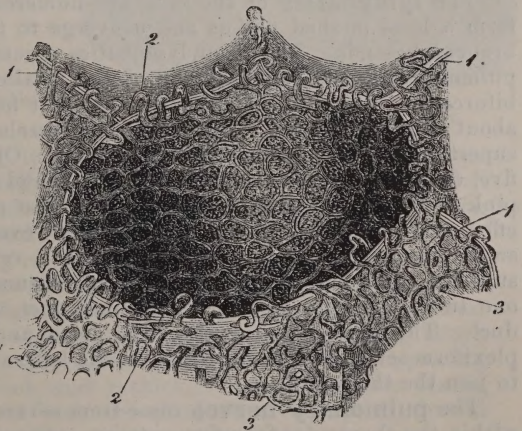


Fig. 461.—Capillary plexus on the wall of an alveolus.

transverse meshes, and send branches to the mucous coat, which communicate with branches of the pulmonary arteries and form a plexus with longitudinal meshes. These capillaries empty themselves into the pulmonary veins, while those of the first and second series of branches open into the vena azygos on the right, and into the superior intercostal vein on the left.

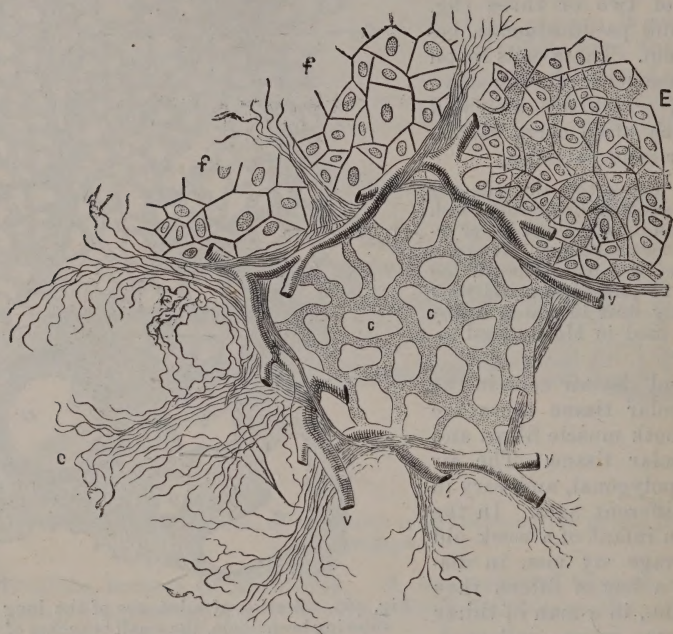


Fig. 462.—Scheme of section of air-cells, showing endothelium, *f*; vessels, *c*; and the elastic tissue of the parenchyma, *e*.

The **lymphatics** of the lung are numerous; the superficial lymph vessels form a loose-meshed plexus and converge to the root, where they end in the bronchial glands. The deep lymphatics accompany the vessels, and unite into pulmonary glands on the walls of the smaller bronchi and in the angles of bifurcation of the tubes. There are at least forty such in the right lung and about thirty in the left. Their efferent vessels emerge at the root, joining the superficial vessels in the bronchial glands. Of these there are about twenty-five, distributed at the roots of the lungs and along the bronchi and trachea; pink in the child, black in the adult, as also are the pulmonary glands. The efferent lymphatics on the right ascend over the vena azygos behind the superior vena cava and right innominate vein, and communicate with the superior right *mediastinal glands*, from whence the efferent vessels unite into one tube, the *right bronchio-mediastinal duct*, which joins the right lymphatic duct. The left lymphatics cross the aorta, and uniting into a single tube or a plexiform set of vessels, dip between the left subclavian and left carotid arteries to join the thoracic duct.

The **pulmonary nerves** come from several sources. Each vagus gives off within the thorax (*a*) four fine *anterior pulmonic nerves*, which pass towards the bifurcation of the trachea, and descend from thence in front of the bronchi to the root, forming a wide-meshed plexus, whose branches are distributed chiefly to the larger bronchi. (*b*) The trunk of the vagus breaks up on the back of the

root into a coarse *posterior pulmonary plexus*, into which also pass branches from the last cervical and four upper dorsal sympathetic ganglia. These form a series of loops on the back of the vessels in the root, from which many fine nerves enter the lung around the vessels, especially around the branches of the bronchial tubes.

210. CONTENTS OF THE SUPERIOR MEDIASTINUM—Thymus Gland.—The superior mediastinum of the adult contains superficially a lobulated fatty mass, the remains of the thymus. This in the foetus was a transversely elongated, pinkish body, made up of two unequal lobes, whereof the right is the larger, and overlies the pericardium, the aorta and the large veins projecting upwards into the neck. Its lobes extend upwards into longer and downwards into shorter cornua. They are divisible into many lobules, each of which is still farther subdivided by septa of the areolar investing tissue. Each ultimate subdivision consists of a cluster of polygonal lymph follicles (fig. 465), each divisible into cortical (*a*) and medullary (*b*) layers embedded in a vascular

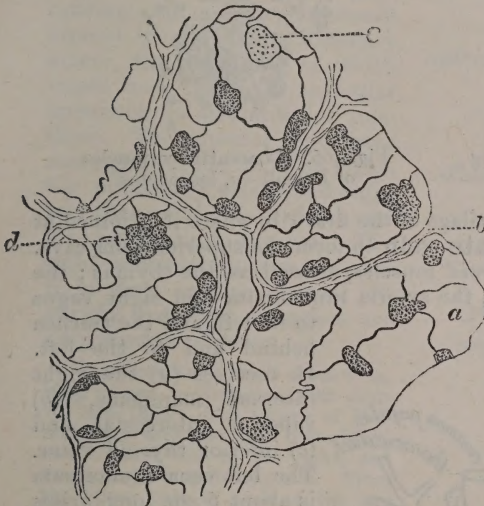


Fig. 463.—Endothelium, showing the granule cells (*c*) and interspaces of air-cells of lung (*a*).

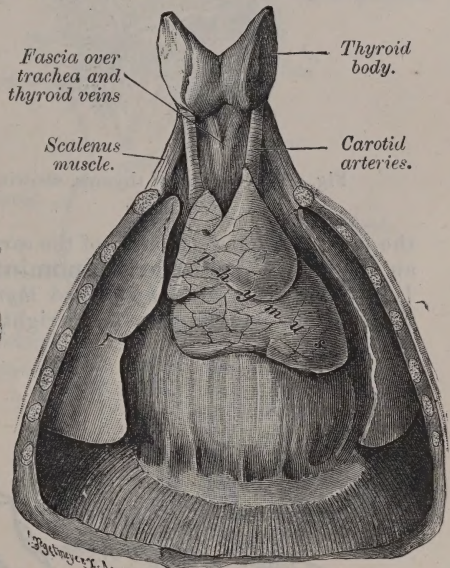


Fig. 464.—Thymus gland at birth.

connective tissue containing many lymph cells. Peculiar concentric masses of cells are distributed in the medullary part of these follicles, each of which contains a large central cell surrounded by an imperfectly laminated epithelium (fig. 466, *b*). These *concentric corpuscles of Hassall* are sometimes very dense.

At birth the thymus was about 5 cm. long by 3.5 by 1. Its weight at birth is about 15 grammes. At two years old this organ attains its largest size and weighs about 25 grammes, and is about 7 cm. long, 4 cm. broad, and 1.5 thick. At six it begins to degenerate, the outer layer of each lobule becoming fatty; by sixteen this change has generally become far advanced, the organ appearing as a fatty mass 5 cm. long, 6 broad, and 1 thick. Large lymphatic vessels traverse it, and their sheaths have been described as a convoluted central canal. The blood vessels are derived from the internal mammary.

There is much evidence in favour of the view that the thymus is derived from the thickened wall of the *precervical sinus* or angle of depression formed at the flexure of the lower part of the neck on the thorax. In this flexure the third visceral arch overlaps the

fourth and the fourth the fifth. The corpuscles of Hassall are derived probably from the epidermal layer, and in the modified corium of the surrounding tissue there has been an enormous overgrowth of lymphoid tissue masking other parts of the structure. In consequence of its source its vessels and nerves are chiefly parietal in origin. Of its exact function little is known, but it seems to be the great functional lymphatic gland of fetal life and infancy.

211. VENÆ INNOMINATÆ.—Under cover of the thymus are the two innominate veins, formed respectively by the junction of the subclavian (§ 420) and common jugular (§ 414) veins of each side (fig. 467). The **right**, about 2 cm. long, begins behind the right sterno-clavicular joint, descends a little forwards to

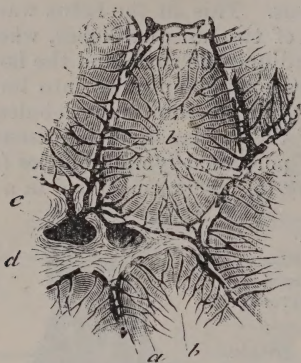


Fig. 465.—Section of thymus, showing its lobules.



Fig. 466.—Concentric corpuscles of Hassall—*a*, leucocytes.

the level of the lower border of the cartilage of the first rib, where it is joined at an angle of 70° by the **left innominate vein** to form the superior vena cava. It underlies the *sterno-hyoid* and *thyroid* muscles, as well as the thymus; the right pleura and lung lie to its right, the arteria innominata and right vagus

to its left, and the trachea behind and to the left. It receives (*a*) the right internal mammary, (*b*) superior intercostal, and (*c*) inferior thyroid veins. The left vena innominata is about 6 cm. long, arises behind the sternal end of the left clavicle, and passes downwards and to the left with a small degree of obliquity. It crosses behind the thymus and pre-sternum, and overlies the left carotid and innominate arteries. It receives on its lower surface the (*a*) left internal mammary, (*b*) thymic, and (*c*) mediastinal veins; on its upper surface (*d*) the left inferior thyroid, (*e*) vertebral, and

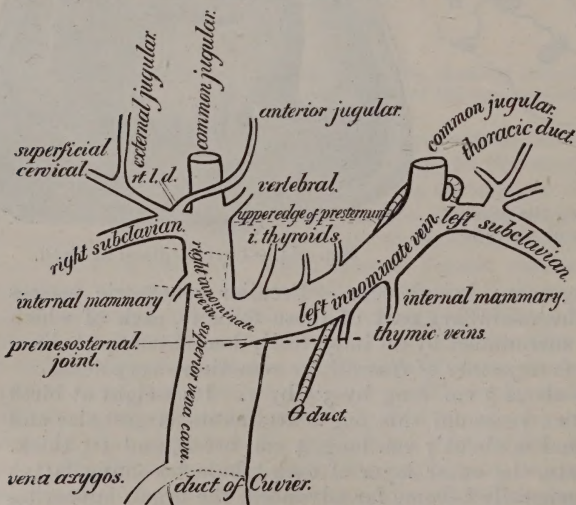


Fig. 467.—Scheme of the tributaries of the superior vena cava. The portion below the vena azygos is the modified right duct of Cuvier.

(*f*) cervicalis profunda veins, most of which have single crescentic valves at their mouths; but there are no other valves in either trunk. In the infant at birth the top of this vein is on a level with the upper edge of the sternum.

212. SUPERIOR VENA CAVA.—This vein is about 7 cm. long and descends with a slight curve, its lower end being behind and to the right of the plane of its upper. Of this course 3 cm. is outside the pericardium, which it enters obliquely below its confluence with the vena azygos. It terminates opposite the third right costal cartilage or the seventh dorsal vertebra by opening into the right auricle. In front lies the thymus; to the right the right lung and pleura; to the left the aorta; and behind, the trachea, vena azygos, right bronchus, right pulmonary artery, and superior right pulmonary vein.

213. THE AORTA arises behind the mesosternum, opposite the lower edge of the third costal cartilage. Its first part, the *bulbus aortæ*, whose three *sinuses of Valsalva* lie above and behind the semilunar valves, is continued upwards, forwards, and to the right as the **ascending** (or ventral) **aorta**, as far as the level of the second costal cartilage (fig. 469, 1).

This portion is enclosed in the fibrous layer of the pericardium, superficial to which it is covered by the lower edge of the thymus and the right pleura. The serous layer of the pericardium makes a common sheath around it and the pulmonary artery, the beginning of which vessel and the right auricular appendix are also anterior relations. The superior vena cava and right auricle lie to its right, the pulmonary artery and right branches of the superficial cardiac nerves lie to the left. The right pulmonary artery, anterior right deep cardiac nerves, left auricle, and right bronchus are its posterior relations.

The ascending aorta is about 6 cm. long, 27 mm. in diameter, with coats 1·6 mm. thick. The *sinuses of Valsalva* are arranged one posteriorly, one anterior and to the right, and one anterior and to the left. From the upper part of each of the two latter arise the coronary arteries. Above the sinus the lumen is nearly circular, but at its upper part it dilates into the *sinus maximus* whose lumen is elliptical and whose long axis is directed backwards and to the left.

The *arch** or **transverse aorta** (fig. 469, 2) begins above the *sinus maximus* behind the presternum and passes backwards, a little upwards and to the left, crossing and slightly curving round the trachea, on the left side of which it turns directly backwards to the left side of the lower border of the fourth dorsal vertebra, where it turns downwards, becoming the dorsal aorta.

On its left surface, which looks a little forwards, it is overlapped by the left lung, and overlapped by the left pleura, under cover of which it is crossed by the

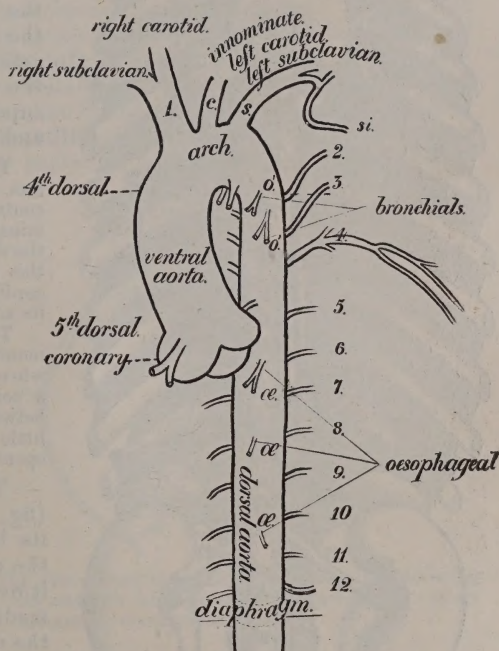


Fig. 468.—Scheme of course and branches of the thoracic aorta.

* It is to be noted that the name *arch* is here limited to what in the older text-books is called the transverse portion of the arch. The so-called ascending portion of the arch is a portion of the ventral aorta, and the so-called descending portion is part of the dorsal aorta.

left phrenic, left superior cardiac branches of the sympathetic and of the vagus, and the trunk of the left vagus, here giving off its recurrent and inferior cardiac branches.

From its upper surface its three branches—the innominate, left carotid, and left subclavian—arise, their origins being crossed by the left vena innominata. At its right and anterior end it is touched by the right pleura and lung, while its right surface looks backwards and to the right, and lies on the trachea, œsophagus, recurrent laryngeal, and all the cardiac nerves except the two which lie in front, the thoracic duct, and left side of the fourth dorsal vertebra. Below its concavity are the left recurrent laryngeal nerve, the left bronchus, the right pulmonary artery, and the ductus arteriosus, to the right and in front of which is the superficial cardiac plexus of nerves and several large lymphatic glands.

This portion of the aorta measures 46 mm. in length, and is 24 mm. in diameter, contracting suddenly to 22 mm. at its termination (*fretum aortæ*) immediately beyond the ductus arteriosus, enlarging again below this point. The fibrous layer of the pericardium becomes inseparably blended with its adventitia on its concave side.

The branches arise close together, the mouths of the innominate and left carotid, when seen from within, being separated by a comparatively sharp edge; the interval between the latter and the subclavian is a little longer, and the left side of each opening is sharper-edged than the right.

To see the **descending aorta** (fig. 469, 3), raise the left lung from its bed and turn it forwards and to the right, dividing the left pleura as it overlies the aorta in the posterior mediastinum. The thoracic stage of the descending or dorsal aorta follows the flexures of the spine, and extends from the fourth to the twelfth dorsal vertebræ, being about 20 cm. long, and diminishing from 23 to 21 mm. in diameter in its course. In front is the root of the left lung and the pericardium, separated from it by the intervention of the œsophagus (*ib.*, 11) carrying with it the vagi. This tube lies above to its right side, but soon winds in front, finally projecting a little to its left side close to the diaphragm. To the right also lies the

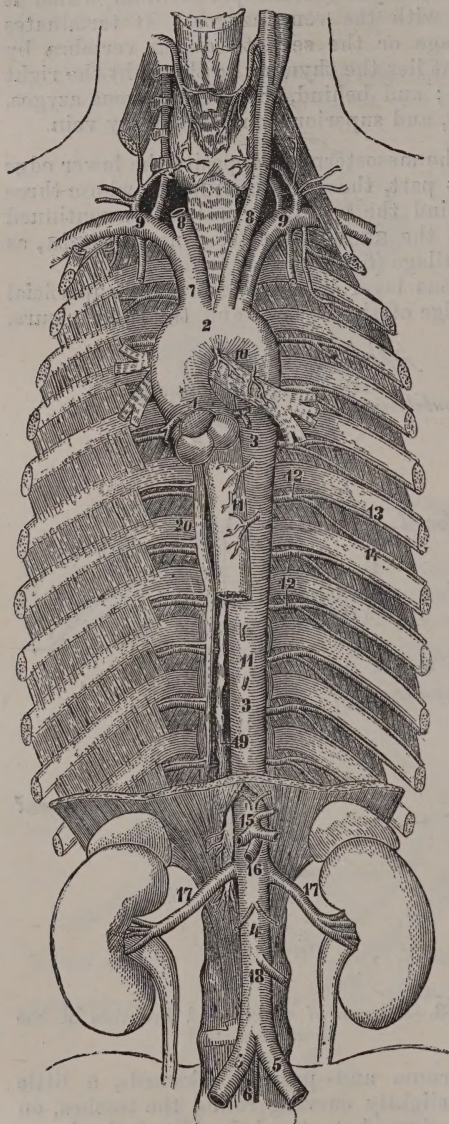


Fig. 469.—The relations and branches of the aorta—4, abdominal aorta; 5, common iliacs; 6, sacral aorta; 7, innominate artery; 8, common carotids; 9, subclavian; 11, œsophagus and œsophageal arteries; 12, intercostals; 13, 14, branches of the intercostals; 15, coeliac axis; 16, superior mesenteric; 17, renals; 18, inferior mesenteric; 19, thoracic duct; 20, vena azygos.

right pleura, the thoracic duct (*ib.*, 19) and vena azygos (*ib.*, 20); to the left it is invested by the left pleura and indents the left lung (fig. 452, *B.r.*). Behind, it lies on the spine, which it crosses with a slight obliquity, at first resting on the left side of the dorsal bodies, but reaches the middle line at the twelfth dorsal vertebra. The vena hemiazygos and the intercostal veins above it cross between it and the spine.

214. BRANCHES OF THE AORTA WITHIN THE THORAX.—The right and left coronary arteries arise from the ascending aorta (p. 321). From the arch the arteria innominata (§ 435), the left carotid (§ 434), and left subclavian (§ 419) arise. From the descending aorta arise nine visceral branches from the front of the aorta (three bronchial, two pericardiac, and four œsophageal); and eighteen intercostal branches, nine on each side arising posterolaterally.

1. The **right superior bronchial** arises close to, often with the uppermost right intercostal branch immediately below, the level of the bifurcation of the trachea. It accompanies the right bronchus into the lung. 2. The **left superior bronchial** (fig. 469, 10) is much smaller, arises a little lower, and accompanies the left bronchus. 3. The **left inferior bronchial** arises below the level of the left bronchus, and is distributed to the lower lobe of the left lung (fig. 468, *o'*). There is, however, much variety in the course of all these visceral branches. 4-5. The **pericardiac** branches are two small vessels supplying the pericardium and the posterior mediastinal lymphatic glands. 5-9. The **œsophageal** arteries (*ib.*, 11) are usually four, and increase in size from above downwards. The first arises below the bronchials, the last a little above the *diaphragm*. They at once enter and break up in the wall of the œsophagus. A few small and rarely injectible branches, very little larger than the ordinary vasa vasorum, pass to the connective tissue of the mediastinum.

The **intercostal** (*ib.*, 12) arteries are usually nine on each side, arising in two vertical rows and supplying the third to the eleventh intercostal spaces. A subcostal artery, similar in nature, underlies the twelfth rib. The

upper three pairs arise opposite the fifth dorsal vertebra, sometimes by a common trunk, and ascend obliquely to their spaces; the others pass out nearly at right angles. Those of the right side are longer, as they have to cross the vertebral bodies, underlying the parts in the posterior mediastinum. When each vessel reaches the space between the side of the vertebra and the superior costo-transverse ligament it divides into two branches, a posterior and an anterior. The former (fig. 470) passes backwards between the transverse processes of contiguous vertebræ with the corresponding dorsal nerve, and opposite the intervertebral foramen divides into two branches, spinal and muscular. The spinal enters the foramen and divides within the spinal canal into three branches, one to the front wall, and one to the back wall of the canal. Each of these makes a regular network of anastomoses, pre-, and retro-neural, with the corresponding vessels above, below, and on the other side.

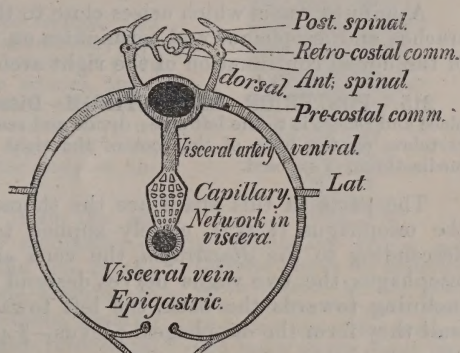


Fig. 470.—Diagram of an intercostal artery, showing its anterior and posterior branches and intermetameric communications.

The third branch pierces the dura mater, and ramifies on the spinal marrow, anastomosing in front with the anterior, behind with the posterior spinal arteries (fig. 470).

The muscular branch emerges behind the transverse processes, and after a short course divides into internal and external branches. The former passes between the *semispinalis* and *longissimus dorsi*, supplying both, and sending a subcutaneous branch which pierces these muscles close to the spinous processes. The external emerges between the *longissimus* and *ilio-costalis*. Minute retro-costal vessels join together the arteries of successive segments.

The anterior intercostal artery lies beneath the pleura, endothoracic fascia, and sympathetic chain, sinking under the *infracostalis*, and between the *external* and *internal intercostal* muscles. A little in front of the angle of the rib each divides into two branches, a small inferior (fig. 469, 14) which runs along the upper edge of the rib below, and a larger superior (*ib.*, 16) which passes in the subcostal groove with its companion nerve below and vein above. These vessels anastomose with each other, and in front with the intercostal branches of the internal mammary. They also send lateral branches into the *serratus magnus* and perforating branches to the *pectoral* muscles, mammary gland, and *serratus magnus*.

In early foetal life all the intercostal vessels pass at right angles or even descend a little from the aorta. The opposite obliquity of the upper vessels appears first in the first year, and is due to the unequal growth of the spine and the aorta. In tapping the thorax the safest mode of avoiding the intercostal vessel is to pierce in the middle or nearer to the lower than the upper part, of the intercostal space, that below the angle of the scapula being generally the one selected.

A minute vessel which arises close to the right bronchial ascends behind the trachea and œsophagus and terminates on the œsophagus. This is the remains of the dorsal continuation of the right arch (§ 430).

215. POSTERIOR MEDIASTINUM—Dissection.—Raise the right lung from its place and reflect it to the left side; divide and remove the pleura as it is reflected from the vertebræ on the back of the root of the right lung; thereby the side of the posterior mediastinum is exposed.

The parts in this space are the thoracic aorta, projecting to the left side, the œsophagus (§ 253), closely applied to the back of the pericardium, and descending to the *diaphragm*, the vena azygos and thoracic duct. Upon the œsophagus the two vagus nerves descend from the root of the lung, the right inclining towards the back, the left towards the front of the tube (on whose wall they form the œsophageal plexus—§ 486).

216. VENA AZYGOS.—To the right of the aorta is the thoracic duct, and still farther to the right is the vena azygos (fig. 471), which, arising in the abdomen, usually from a branch of the ascending lumbar vein, ascends through the aortic opening of the *diaphragm*, and lies on the front of the vertebral column, crossing the right intercostal arteries as far as the fourth dorsal vertebra, where it turns forwards above the root of the right lung to join the superior vena cava. It receives on its right side the intercostal veins, from the eleventh to the fourth, on the left the vena hemiazygos at the eighth dorsal and the hemiazygos accessoria still higher. In front it receives the three œsophageal, two pericardiac and several small mediastinal veins, and close to its end the right bronchial. This vein possesses a few imperfect valves, but very few, except the uppermost, of its intercostal tributaries have valves at their mouths, although a few valves occur in the course of the intercostal veins. The pleura is so tightly fastened to the vena azygos on the level of the openings of the intercostal vein that it holds the vein open when it is cut across, and the motions of the ribs alternately make tense and relax the venous wall.

The **hemiazygous vein** on the left side arises below from a small branch

of the ascending lumbar vein, which, piercing the diaphragm, receives the left subcostal vein, and as it ascends on the left side of the vertebral column crossing over the left intercostal arteries, it receives the four lower intercostal veins of its side, and passing behind the aorta over the seventh dorsal vertebra, receives the lowest œsophageal vein and joins the vena azygos.

The blood of the two topmost right intercostal veins (whose artery comes from the subclavian) is returned by a special channel which ascends to join the right vena innominata. The third joins the fourth vein, and ends with it in the vena azygos.

The four left intercostal veins, from the sixth to the third, vary in their course. Two or more of them usually unite into a single trunk, the **v. hemiazygos accessoria**, which descends and crosses the seventh dorsal vertebra above, or even united to the v. hemiazygos to join the vena azygos. The third, sometimes united with the fourth, passes independently across the aorta to the left vena innominata. The accessory vein is usually prolonged upwards as a small channel which crosses the left side of the arch of the aorta obliquely, receives the intercostal veins from the first and second interspaces, and ends in the left vena innominata.

The relations of these structures to the vestigial vein and other parts of the system of the cardinal veins has been already discussed. The radicles of the intercostal veins correspond with those of their companion arteries, above which they lie in the subcostal groove; when they reach the intervertebral and intertransverse foramina, they receive each a dorsal branch from the spinal system of veins, as well as several vertebral veins from the body of the vertebra.

The thoracic duct ascending from the abdomen (§ 295) enters the posterior mediastinum by the aortic opening, and lies to the left of the aorta and to the right and on a plane anterior to the vena azygos. It is, while in this space, close to the right pleura and lies on the right intercostal arteries, the hemiazygos vein and the areolar tissue of the mediastinum. At the fifth dorsal vertebra it passes across the middle line to the left side, and enters the superior mediastinum posterior to the aortic arch and to the œsophagus, becoming ultimately a left relation of the œsophagus, between which and the left pleura it ascends to the upper opening of the thorax, out of which it rises into the neck (§ 420). The thoracic portion of the thoracic duct is about 35 cm. long, very sinuous, and when inflated from below it appears nodulous, owing to the dilated portions which lie above each pair of its numerous valves. There are more valves in the short, superior mediastinal stage than in the longer, posterior mediastinal. The duct often breaks up into a plexus, especially in the superior mediastinum. It receives the pleural, intercostal, and left pulmonic lymphatics in its thoracic stage. It usually dilates about the level at which it crosses the spine.

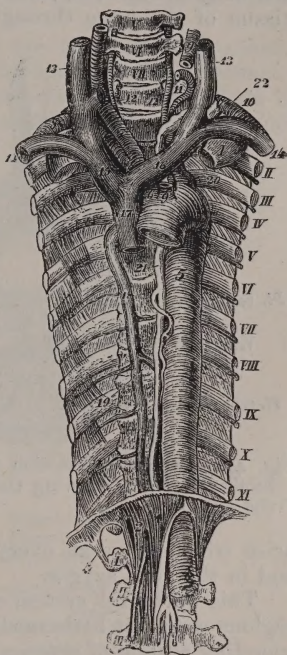


Fig. 471.—Vena azygos and thoracic duct in the posterior mediastinum.—I, II, &c., ribs; above, the same kind of figures are on the cervical and below on the costal processes of the lumbar vertebrae. 1,2,3,4,fascicles of diaphragm; 5, dorsal aorta; 6, innominate artery; 9, left carotid; 10, subclavian; 11 is between the thyroid (leftward) and the vertebral; 12, right vertebral; 13, common jugular vein; 14, subclavian vein; 15, right innominate vein; 16, left innominate vein; 17, superior vena cava; 18, vena azygos; 19, vena hemiazygos; 20, superior intercostal vein of left side; 21 and 22, thoracic duct.

217. VEINS OF THE DORSAL VERTEBRÆ.—The veins of the vertebral column are large and plexiform. Within the spinal canal there are four vertical trunks—one on each side of the posterior common spinous ligament, and one on each side of the laminae, the **anterior** and **posterior longitudinal spinal veins**. These are united by cross branches; the two anterior are joined by large plexiform *anterior transverse branches* which cross the back of the body of each vertebra, and receive the *basivertebral veins* from the cancellous tissue of the bone through the pair of holes in the back of the body. The

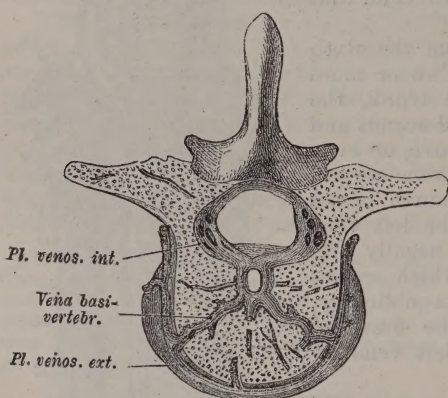


Fig. 472.—Horizontal section through body of lumbar vertebra, showing the arrangement of the veins.

anterior and posterior are joined by a *lateral transverse branch* on the inside of each pedicle, and the two posterior are joined by smaller *posterior transverse branches* which lie on the interlaminar ligament. There is thus a system of transverse venous rings on each metamere into which the spinal, meningeal, and cancellous veins discharge their blood. Through each intervertebral foramen there emerges an outflowing *ramus spinalis* which joins an extra-vertebral *plexus dorsalis* of veins investing the outside of the laminae, and which is longitudinally continuous from the sacrum to the skull. Into this the veins which accompany the dorsal branches of the intercostal arteries pass, and from these the dorsal veins

arise which open at every interspace into the intercostal veins before these end in the vena azygos.

This vertebral system of veins which extends into the cervical and lumbar regions with but little modification, is in capacity much larger than the corresponding system of arteries.

218. THE CARDIAC NERVES, whose origins are seen in the neck (§ 488), unite to form a plexus as they enter the thorax, and lie partly in front, partly behind the aortic arch. The superior left cardiac, and the inferior left vagus-cardiac from the recurrent laryngeal, lie over the aorta between the vagus and the phrenic nerves, and descend on the front of the pulmonary artery to form part of the anterior cardiac plexus.

The three right cardiac nerves and the middle and inferior left, with the right vagus cardiac, lie behind the aorta. To see them, divide the superior vena cava as it enters the pericardium, cut the aorta at the sinus maximus and at the ductus arteriosus, and raise the arch. The nerves can now be seen forming a plexus in front of the bifurcation of the trachea, behind the aorta and above the right pulmonary artery. From this the branches descend in two streams right and left.

The right branches pass between the aorta and the pulmonary artery, and some run forwards and join the anterior cardiac plexus, which is distributed to the front of the heart, to the pulmonary artery and aorta, and in which there is sometimes a small ganglion beneath the aortic arch, the cardiac ganglion of Wrisberg. Most of the right branches, however, enter the right auriculo-ventricular groove with the left coronary artery, and form the anterior coronary plexus. From this pass branches to the right auricle, to the right ventricle, as well as to the front of the aorta, along which they pass, even being continued on

its primary branches to the neck. Some are continued on the superior vena cava and left pulmonary veins. The left branches are the larger and more numerous, and pass beneath the left pulmonary artery to form the posterior coronary plexus which runs on the hinder wall of the heart in the auriculo-ventricular groove, and sends branches along the pulmonary arteries to both lungs to join the anterior pulmonic plexuses in the roots of the lungs. Minute ganglia connected with these permeate the heart substance especially around the auriculo-ventricular groove.

The eleven **intercostal nerves** on each side are the ventral branches of the dorsal spinal nerves. As each emerges from its intervertebral foramen it gives off two branches to the corresponding sympathetic ganglion. Each lies at first between the pleura and the external intercostal muscle placed usually

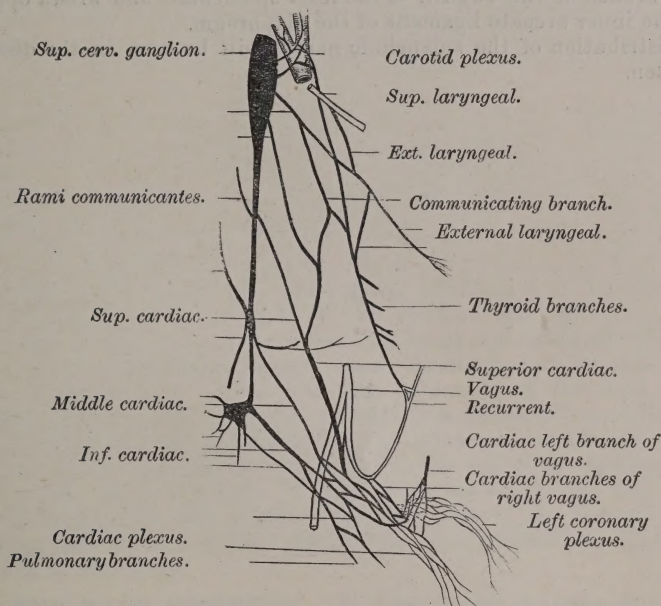


Fig. 473.—Diagram of cardiac nerves.

below its accompanying vessels, except for the upper three, which are crossed by these vessels. It then enters the space between the outer and inner intercostal muscles, finally lying in the internal intercostal muscles as far as the sternum, where it ends by becoming the anterior cutaneous nerve. They give off in their course lateral muscular and lateral cutaneous nerves.

Thoracic Sympathetic System.—A chain of lateral ganglia is placed behind the pleura on each side, the upper ten resting on the fronts of the rib-heads, the lowest pair on the vertebral bodies. Each ganglion is small, irregularly fusiform, greyish, joined to its predecessor and successor by a thin grey nerve-cord, and receiving two rami communicantes, one white, the visceral branch of the anterior division of the corresponding spinal nerve, and one grey. The latter consists of grey non-medullated fibres which are lost in the ganglia, but the chief thickness of the former consists of small white medullated fibres (about $2\ \mu$ in diameter), which are probably vasomotor and visceroinhibitory fibres, and which leave the ganglia in their inner or collateral branches. The collateral branches of the five upper thoracic ganglia are small, and are distri-

buted chiefly on the aorta, pulmonary artery, and structures in the superior mediastinum. They form on the thoracic aorta a fine-meshed plexus, which receives a contingent from the cardiac plexus. Other branches communicate with the posterior pulmonic plexus of the vagus, a few fine branches are distributed to the thoracic duct and vena azygos, and to the vertebral veins.

The collateral branches from the sixth, seventh, eighth, and ninth, and sometimes from the tenth, are strong white cords which pass inwards, converging, and unite successively in the posterior mediastinum to form the **great splanchnic nerve**. This lies on the vertebral bodies, and enters the abdomen by piercing the crus of the diaphragm (§ 315). The collateral branches from the tenth and eleventh unite to form the lesser splanchnic, which descends external to the greater splanchnic and also pierces the diaphragm. The collateral branch of the twelfth is the least splanchnic, and arises opposite the level of the inner arcuate ligament of the diaphragm.

The distribution of the splanchnic nerves will be seen in the dissection of the abdomen.

THE ABDOMEN.

219. A staff having been passed into the urethra, the body is to be placed on its back with the thighs flexed and abducted. It may be retained in this position by tying it, or, still better, by placing it on a *perineum frame*, such as that used in Cambridge.

The **perineum** is the narrow interval between the thighs, consisting of a hinder part or anal region and a fore or genito-urinary, which may be marked off from each other by a curved line drawn from one ischial tuberosity to the other in front of the anus.

The tubera ischii can be felt through the soft parts at either side, and the point of the coccyx is palpable behind, lying in the median depression (**crena clunium**). In front of its tip the skin is occasionally sunk into a dimple, the rudimental *subcaudal fold*. The rounded margin of fatty tissue which descends below the lower edge of the gluteus maximus can be felt passing outwards from the coccyx and forming the fold of the nates. Farther forward and on each side the ischio-pubic rami and the tubera cavernosa (p. 166) can be felt.

The anal orifice appears as an irregular elliptical opening about 2 cm. long, placed about 3 cm. in front of the coccyx. Its border is somewhat puckered, the vertical folds of the wrinklings being continued upwards into the rectum as ridges (**columnæ recti**), which diminish, but do not completely disappear, on distension. The pale thin epidermis of the anal margin is prolonged for about 7 mm. inwards, and ends in a crenated zone of transitional epithelium, which becomes cylindrical on the columnæ. A circle of very large and often modified sweat glands opens close to the end of the cutaneous area.

During life, when the body is bent forwards on hands and knees, on dilating the anal orifice, two or three crescentic folds of the mucous membrane of the rectum can be seen at some distance up in the intestine. These will be described at a later stage.

220. THE MALE PERINEUM.—In front of the anus the skin is marked by a distinct median **raphé**, continued forwards along the middle line of the scrotum to the under side of the penis. An inch in front of the anus there is a slight median swelling, corresponding to the bulb of the urethra, on each side of which the roots of the corpora cavernosa penis can be felt.

The perineal epidermis is deeply pigmented and about 0.15 mm. thick. The corium has few papillæ and is 1 mm. thick medially, but becomes much thicker over the tubera ischii: it appears wrinkled towards the scrotum. The hairs are directed forwards and inwards anteriorly, but are divergent around the anus, behind which they converge towards the coccyx, and are usually about 18 to the sq. cm. Sweat glands are few and usually small, 42 to the sq. cm.; sebaceous glands are also small. There are numerous papillæ in clusters close to the verge of the anus, which, when diseased, may become large and clustered, forming condylomata.

Dissection.—Fasten by a stitch the fundus of the scrotum to the prepuce and tie the handle of the staff forwards. Distend the rectum moderately with tow wet with spirit, and stitch the margins of the anus together. Divide the skin in the middle line from the root of the scrotum to the coccyx, the incision being carried on each side of the anus. From each end of this line cut outwards at right angles for an extent of 10 cm. and reflect the flaps of skin outwards.

Close to the verge of the anus the skin is with difficulty separable, and in

the cutis there are scattered radiating fascicles of unstriated muscular fibres (*corrugator cutis ani*), not making a continuous layer. The anal veins lie close to the skin along the edge of the opening, and often present varicosities which, when large, constitute external piles. By removing these the superficial sphincter is exposed.

On removing the subcutaneous tissue in front of the coccyx, a small lobulated body, the

coccygeal glomerulus, is brought into view. This is about 2 mm. in diameter, embedded in the connective tissue and attached by a pedicle formed of the end of the middle coccygeal artery and a sympathetic nerve filament, which pierces the fibrous tissue in front of the coccyx. This stalk is the termination of the dorsal aorta, and the glomerulus consists of the condensed and convoluted metameric dorsal arteries of the caudal segments embedded in tissue, which is possibly a small persisting fragment of the neurenteric canal. The arteries are dilated into little aneurismal varicosities, with strong muscular coats. From these capillaries arise, and end in small veins. A few

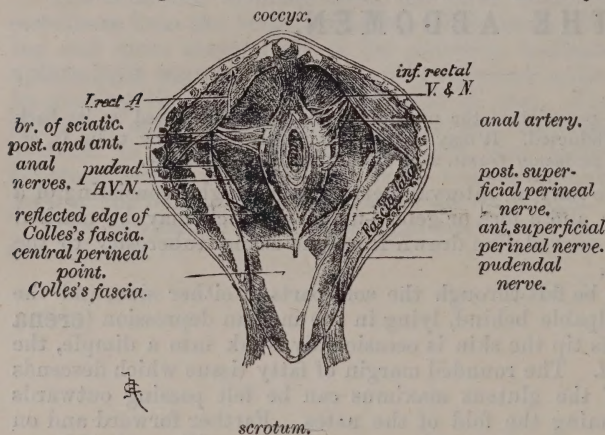


Fig. 474.—Superficial dissection of the perineum, showing the superficial nerves.

nerve fibres and one or two ganglion cells are scattered in the stroma of the organ. It is occasionally the seat of cystic enlargement, and sometimes is a centre of neuralgic pain.

221. THE SUPERFICIAL SPHINCTER ANI consists of curved fascicles running sagittally on each side of the orifice and divisible into two strata, a superficial subcutaneous, and a deeper, which lies close to the intestinal wall. It arises behind from the firm areolar median band (**ano-coccygeal ligament**) (fig. 478, 17), which stretches from the coccyx to the skin of the hinder angle of the anus. The fibres run forwards, forming a flattish, obliquely directed plane of muscle, and are inserted, the superficial into the skin of the preanal median line, the deeper partly into the deep fascia at the central perineal point (p. 357), partly into the *bulbo-cavernosus* muscle (p. 358), some outer fibres run directly into the *levator ani*, and a few of the innermost cross the median line decussating their fellows. One slender fascicle passes round the front of the opening from side to side, closely applied to the deep sphincter.

By its tonic action it keeps the anus closed, but it may be forcibly contracted, and so can resist the expulsive force of the muscular wall of the rectum. It is supplied by the fourth sacral nerve.

The other deep structures of the anal wall are described in connection with the ending of the rectum, and will be subsequently seen (§ 260). The superficial sphincter is essentially a subcaudal sling, segmented from the *levator ani*, constricting the anus and suspending it to the vertebral column.

222. ISCHIO-RECTAL FOSSA.—The superficial fascia, almost absent over the sphincter, thickens enormously on each side, filling with coarse-grained fat the space between the rectum and the tuber ischii, and forming a lateral elastic support for the end of the rectum, which it keeps closed by its pressure.

Remove this fat piecemeal, commencing behind at the edge of the *gluteus maximus*, the fascial investment of which is to be cleaned. Here two perineal branches of the small sciatic nerve, and a branch of the sciatic artery (fig. 474, *I. rect. A*), cross from beneath the

edge of the muscle to supply the skin. Preserve these as well as the two anal arteries which pass through the fat transversely, farther forward, from above the tuber ischii to the verge of the anus.

The ischio-rectal fossa is a wedge-shaped space, whose outer perpendicular wall is formed by the **obturator fascia** above the tuber ischii, and whose inner oblique wall is the thin **anal fascia** covering the *levator ani*. It is closed above by the junction of these fasciæ, the angle of union receding

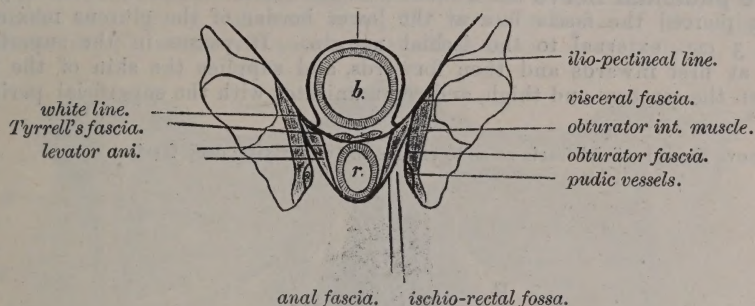


Fig. 475.—Diagrammatic section of pelvic fascia, showing the fascial boundaries of the ischio-rectal fossa.

gradually as the fossa deepens to a narrow point towards the spine of the ischium. Its hinder limit superficially is the edge of the *gluteus maximus*, whose investing fascia tucks inwards to be attached to the underlying greater sciatic ligament. Its front wall is a fold of the deep fascia, stretching from the front of the tuber ischii to the central perineal point.

The **pudic artery** (fig. 481) lies in a canal in the obturator fascia, about 2 cm. above the edge of the tuber ischii. Its anterior and posterior anal branches pierce the fascia and pass transversely through the fat to the structures bounding the anus, anastomosing with each other and with the inferior rectal arteries. The anal branch of the pudic nerve passes with the anterior artery to supply the skin of the verge of the anus. Piercing the *levator ani* near the coccyx is the anal branch of the fourth sacral nerve which supplies the *sphincter*.

In front of the anal arteries the perineal nerve leaves the pudic artery and becomes superficial by piercing the fascia; dividing into two branches, a superficial, which passes forwards over the deep fascia to supply the skin of the perineum and scrotum, and a deeper, which again passes through the deep fascia at its reflection (see below) and enters the *inter-muscular space*, to be distributed to the perineal muscles.

Over the tuberosities of the ischia the superficial fascia is thick and laminated, traversed by fibrous bands which tie the skin to the bone or to the wall of a bursa (*bursa ischiatica*), which is irregular, often compound, and crossed by smooth round cords clothed with endothelium.

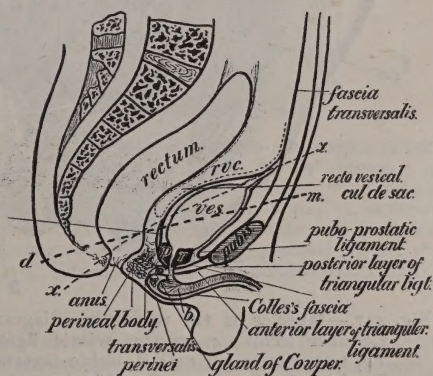


Fig. 476.—Deep investing fascia of perineum (Colles's fascia), seen in vertical section.

In the urethral region the superficial fascia is thinner, and laterally continuous with that of the thigh. It becomes still thinner towards the scrotum, and here it contains many fascicles of involuntary muscle, and is called the **dartos** (§ 244). In the middle line the superficial fascia is united both to the skin and to the deep fascia, so that infiltrations pass with difficulty from side to side, and only small vessels cross this line.

The **pudendal nerve** lies a short distance outside the ischial rami (§ 325), having pierced the fascia lata at the lower border of the gluteus maximus, about 3 cm. external to the ischial margin. It passes in the superficial fascia at first inwards and then forwards, and supplies the skin of the fold between the scrotum and thigh, and communicates with the superficial perineal nerve.*

Remove the superficial fascia so as to expose the underlying deep fascia.

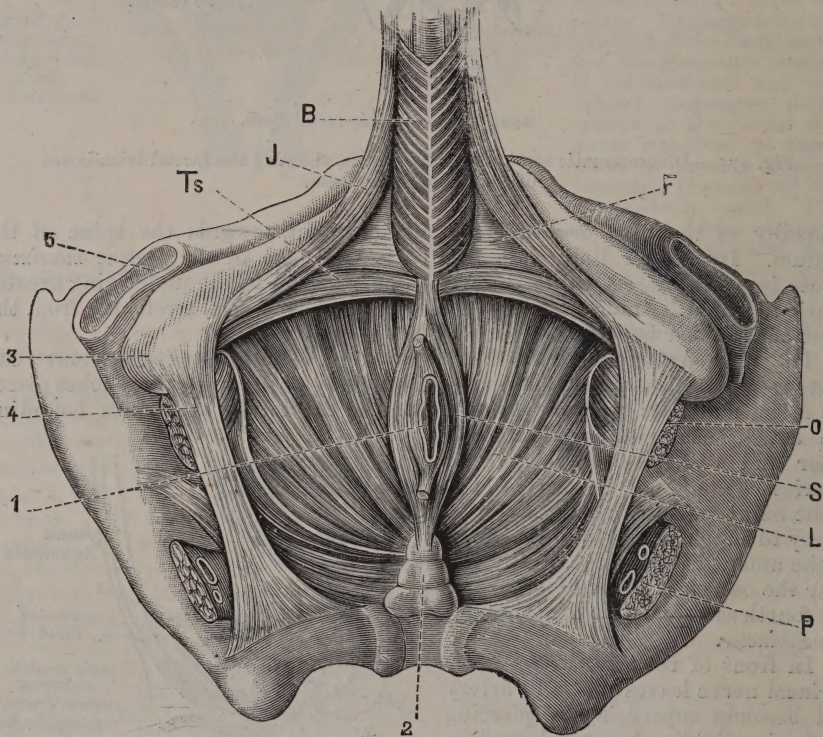


Fig. 477.—Muscles of the perineum, diagrammatically represented—1, anus; 2, coccyx; 3, tuber ischii; 4, greater sciatic ligament; 5, acetabulum; B, bulbo-cavernosus; Ts, transversus perinei; J, ischio-cavernosus; F, anterior layer of triangular ligament; O, obturator internus; S, sphincter ani; L, levator ani; P, pyriformis.

223. THE DEEP PERINEAL FASCIA OR COLLES'S FASCIA is a thin membrane attached on each side to the rami of the ischium and pubis, and continuous in front into the deep fascia of the penis. In the middle line it is

* The dissector should make out the nerves and vessels, as well as the muscles and fasciae on both sides; nothing but confusion arises from making a more perfect dissection on one side than on the other; it does not add to the facility with which the dissector does his work, and only teaches bad habits to scamp one half of the work by cutting away parts without seeing them properly.

with difficulty separable from the overlying superficial fascia and from the underlying raphe of the *bulbo-cavernosus* muscle, at the hindmost end of which it receives the attachments of the *sphincter ani* and *transversus perinei*, and this strengthened spot is called the **central perineal point**. From this outwards, on each side, the deep fascia is reflected around the hinder border of the *transverse perineal* muscle (fig. 477, Ts), so forming an anterior boundary for the ischio-rectal fossa; and turning upwards behind that muscle it is continued forwards as a strong reflected layer, the anterior layer of the triangular ligament (*ib.*, F), which will subsequently be seen on a deeper plane.

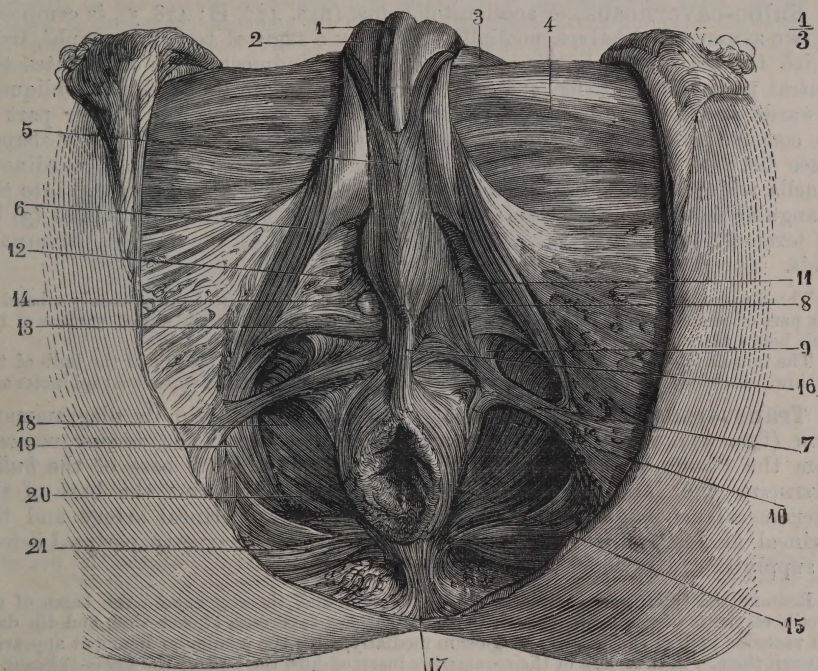


Fig. 478.—Perineal muscles as commonly met with—1, corpus spongiosum; 2, corpus cavernosum; 3, scrotum; 4, fascia lata; 5, bulbo-cavernosus; 6, ischio-cavernosus; 7, transversus perinei, sending 8, fibres into bulbo-cavernosus; 9, border from which Colles's fascia has been cut; 10, anomalous bundle of fibres passing to anus; 11, anterior layer of triangular ligament; 12, compressor urethræ; 13, ischio-bulbosus; 14, Cowper's gland; 15, superficial sphincter; 16, insertion of last into central perineal point; 17, anococcygeal ligament; 18, levator ani; 19, obturator fascia; 20, ischio-rectal fossa; 21, gluteus maximus.

A little above its border of reflection Colles's fascia is connected on its deep surface by a dense areolar web with the obturator and anal fasciæ, thus closing in the ischio-rectal fossa in front.

By inserting the point of a blowpipe under this fascia at one side it is possible to inflate the subfascial region, and to blow air from hence forwards into the scrotum and root of the penis, but not into the ischio-rectal fossa. Divide this fascia along each side of the middle line and along its posterior border. On reflecting the flaps outwards three muscles are exposed on each side bounding an *intermuscular triangle*, wherein run the superficial perineal vessels and nerves.

224. ISCHIO-CAVERNOSUS or erector penis (figs. 477, J; 478, 6), the outermost muscle, arises from the lower and inner border of the tuber

cavernosum as far back as the front of the tuber ischii. Its fibres form a thin lamella, passing obliquely forwards on the inner and under side of the corpus cavernosum penis (fig. 478, 2), into the capsule of which they are inserted by short tendinous fibres.

The inner and outer fascicles are sometimes separate at their insertion, and one of the latter slips sometimes, though rarely, passes outside and above the corpus cavernosum to be attached to the true suspensory ligament of the penis (Houston's *compressor venæ dorsalis penis*). The fascicles of this muscle are short, and supplied by the deep perineal nerve. They depress and compress the crus penis.

Bulbo-cavernosus, or accelerator urinæ (figs. 477, B; 478, 5), is composed of two symmetrical halves, medially united by a sagittal tendinous raphé, from which the fibres of each side arise, and whose hindmost point constitutes the central perineal point (fig. 478, 16). From this origin its fibres pass obliquely upwards and forwards on each side, enveloping the bulb and hinder part of the corpus spongiosum of the urethra, the foremost fibres leaving a V-shaped space between them as they diverge. It is inserted (1) into a tendinous lamella which overlies the corpus spongiosum in front of the bulb, (2) into the triangular ligament on each side of the bulb by its hindmost fibres, and (3) by its foremost fibres into the under and outer side of the corpora cavernosa penis.

The fibres of the first set are often distinct from the others. Not uncommonly a band of this part of the muscle is inserted into an expansion, which covers the dorsal surface of the penis below the pubes (*compressor venæ dorsalis penis* of Kobelt).

The muscle is supplied by the deep perineal nerve, and is a compressor of the bulb of the urethra. Its hindmost fibres are continuous with the outer fibres of the superficial sphincter ani.

Transversus perinei, variable, and seldom present in its diagrammatic form (figs. 477, Ts; 478, 7), arises behind and above the *ischio-cavernosus* from the ramus of the ischium, and is inserted into the base of the *bulbo-cavernosus* and into the central perineal point. It forms the base of the intermuscular triangle, and is crossed by the long perineal artery and the perineal nerves, and is accompanied inwards by the transverse perineal artery to supply the parts which cover the bulb.

Remove the *ischio-* and *bulbo-cavernosus* muscles and thereby expose the bases of the erectile elements of the penis, the white-coated corpora cavernosa at each side, and the dark and vascular bulb of the corpus spongiosum medially, with the triangular ligament appearing between them. A deep slip of the *transversus* inserted into the bulb is the *ischio-bulbosus*.

To see the ligament more clearly remove the *transversus perinei* without injuring the long perineal vessels and nerves which cross it, define the edge of the bulb as it lies in front of this membrane, and detach one corpus cavernosum from its bony attachment and reflect it forwards. In doing so the artery of the cut corpus cavernosum is divided as it pierces through the triangular ligament to enter the erectile tissue.

225. THE ANTERIOR LAYER OF THE TRIANGULAR LIGAMENT consists of transverse bundles of white fibrous tissue (fig. 478, 11) laterally attached to the rami of the ischium and pubis, between which it closes the pelvic aperture anteriorly and below, and so separates the perineal from the intrapelvic muscles. Anteriorly it is lost on the front of the sub-pubic ligament, and in its present condition in the dissection it appears posteriorly to have a doubly crescentic base behind (*ib.*, 9), each concavity starting from the central tendinous point. This line is artificial and was made by the dissecting away of the deep fascia, which here turned round the edge of the *transversus perinei* and was reflected. This anterior layer of the triangular ligament is the upward and forward specialised extension of Colles's fascia.

The continuity of the deep perineal fascia and the base of the anterior layer of the triangular ligament is of surgical importance, as thereby extravasated urine from a ruptured urethra is prevented from infiltrating the ischio-rectal fossa, and its course is directed forwards towards the scrotum and root of the penis.

Directly below the sub-pubic ligament the dorsal vein of the penis pierces the apex of this membrane medially to enter the pelvis. On each side of this the terminal branch of the pudic artery (dorsal artery of the penis) pierces it to pass forwards on the penis. The urethra pierces it in the middle line an inch below the pubis, and carries a sheath of the membrane along with it forwards. On each side of the urethral orifice is the opening for the artery of the bulb which here enters the corpus spongiosum; farther forward, and close to the pubic ramus is the hole for the artery of the corpus cavernosum (fig. 480).

Remove now the staff from the urethra, and having divided the triangular ligament vertically on one side of the median line, dissect it off the underlying parts, leaving the urethra in situ, at the same time slit backwards the sheath of the obturator fascia wherein the pudic artery is enclosed so as to expose this vessel on the outer wall of the ischio-rectal fossa.

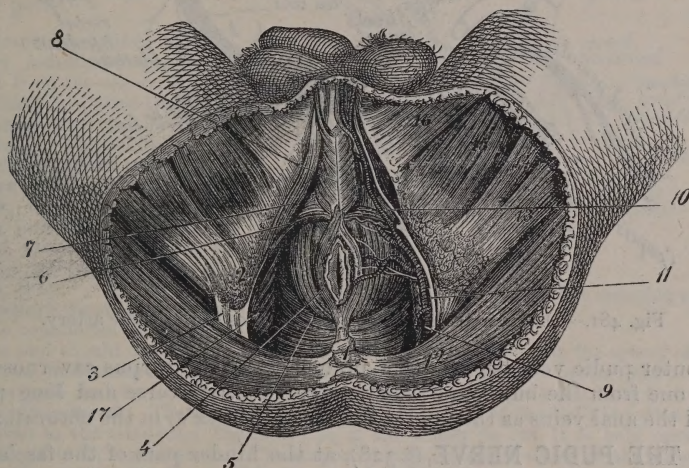


Fig. 479.—Dissection of the perineum, showing the vessels and nerves on the left, the muscles on the right—1, coccyx; 2, tuber ischii; 3, great sciatic ligament; 4, superficial sphincter; 5, levator ani; 6, ischio-bulbosus; 7, ischio-cavernosus; 8, bulbo-cavernosus; 9, pudic artery, third stage; 10, *ibid.*, fourth stage; 11, pudic nerve.

226. THE PUDIC ARTERY (§§ 222, 287) runs between two veins, either of which is larger than itself, and is accompanied by the pudic nerve above, and by the perineal nerve below. On the outer wall of the ischio-rectal fossa it has given off the **anal** arteries, and as it is about to pass between the layers of the triangular ligament it gives off **transverse** and **long** or **superficial peri-**

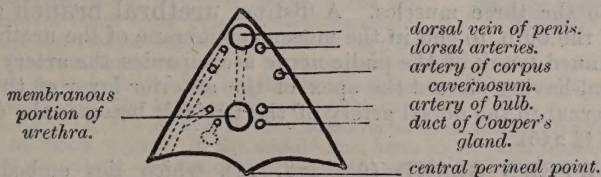


Fig. 480.—Diagram of the perineal face of the triangular ligament.

neal branches. The former runs inwards towards the middle line over the *transverse perineal* muscle, but only communicates with its fellow by minute branches. The latter pierces the reflected edge of the deep perineal fascia where it joins the base of the anterior layer of the triangular ligament, and crosses the *transverse perineal* muscle, passing forwards in the intermuscular

triangle, at the apex of which it enters the *septum scroti*, wherein it terminates by anastomosing with the pubic branches of the femoral artery (§ 343). The pudic, having passed beneath the anterior layer of the triangular ligament, gives off the **artery of the bulb**, a large branch which pierces the ligament beside the urethra to supply the erectile tissue of the bulb and the neighbouring part of the corpus spongiosum, before entering which it sends a small branch backwards to Cowper's gland. Farther forward the pudic gives off a small **urethral branch** to the corpus spongiosum, the **artery to the corpus cavernosum**, and ends as the **dorsal artery of the penis**.

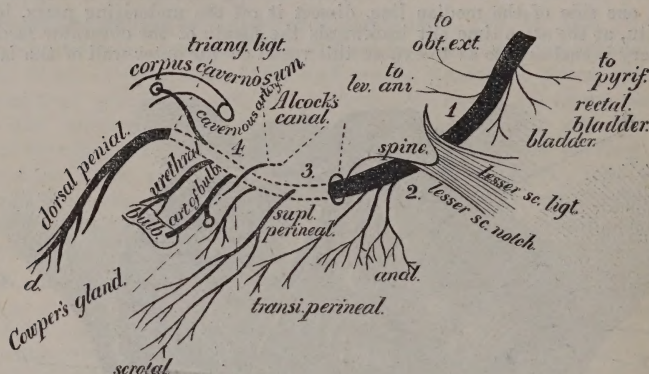


Fig. 481.—Diagram of the course and branches of the pudic artery.

The outer pudic vein begins by a branch from the corpus cavernosum, the inner by one from the bulb, and they receive the transverse and long perineal veins and the anal veins as they enter the canal (Alcock's) in the obturator fascia.

227. THE PUDIC NERVE (§ 328), at the hinder part of the fascial canal, divides into three branches, an anal, already seen crossing the ischio-rectal fossa; a perineal, which lies below the artery and separated from it by a thin fascial septum. This branch divides at the anterior part of the fossa into three branches, two superficial and one deep (fig. 482). The posterior superficial passes outwards in the superficial fascia to run parallel to and communicate with the long pudendal nerve, with which it is distributed to the scrotal skin; the anterior superficial passes inwards on each side of the middle line over the deep perineal fascia, to be distributed to the inner and back part of the scrotum (fig. 474). The deep perineal nerve pierces the base of the triangular ligament beneath the *transverse perineal* muscle, and is distributed to the three muscles. A distinct **urethral branch** accompanies the artery of the bulb, to end in the mucous membrane of the urethra.

The continued trunk of the pudic nerve accompanies the artery lying to its outer side, and having pierced the apex of the anterior layer of the triangular ligament external to the dorsal artery of the penis, it becomes the dorsal nerve of that organ (§ 236).

228. COWPER'S GLAND (fig. 478, 14), which lies embedded in the muscular tissue posterior to the artery of the bulb and under cover of the triangular ligament, is a lobulated pea-like body about 4 mm. long, recognised in a fresh body by its lighter colour, and placed about 6 mm. from the middle line on a plane behind the urethra. It is made up of large acini with wide lumina, invested by a fine connective capsule, and with much involuntary muscular tissue in its parenchyma (fig. 483). Its duct is a fine white tube about 4 cm. long, which passes through the tissue of the bulb, and having run for a short

distance beneath the mucous membrane, opens into the anterior part of the bulb of the urethra. This gland becomes indistinct in bodies of advanced age.

Urethral Muscle.—On a plane deeper than the pudic artery and its branches lies a layer of muscular fibres (fig. 478, 12) attached laterally by a usually narrow origin to the edge of the pubic ramus, and inserted medially into the wall of the urethra, some fibres passing in front and some behind that canal into the central perineal point.

The transverse fibres of this series are sometimes needlessly separated from the others, and to them specially is applied the name **compressor urethræ** or Guthrie's muscles. The oblique fibres which, arising highest are inserted lowest, are called the **levator urethræ**, or Wilson's muscles, while the posterior transverse set are called **ischio-bulbosus**, or *transversus profundus perinei* (ib., 13, see p. 358).

At this stage the student should review the boundaries of the perineal space and should observe the relations of the pudic artery and the artery of the bulb to the rectum and urethra. In the operation of lateral lithotomy the urethra has to be opened behind the bulb and its artery, consequently it is of vital importance that their relations should be remembered. The adventitious coat of the artery of the bulb is united by a close web of fibres to the triangular ligament; so, if the artery be cut, it is held open, and its bleeding is apt to be troublesome. The surgeon's knife enters the base of the intermuscular triangle in the second incision in lithotomy, and divides the *transversus perinei* muscle and artery and the base of the triangular ligament.

The dissection having been carried thus far, by raising the *compressor urethræ* muscles, the inferior surface of the sub-pubic fascia, or deep layer of the triangular ligament, is brought into view. This structure posteriorly has become united to the base of the anterior layer of the ligament with which it is partially in contact; and the pudic vessels and nerves, Cowper's glands, the *compressores urethræ*, and the urethra itself are spoken of as between the layers of the ligament. Careful dissection demonstrates that the anterior layer of the triangular ligament, as above described, is a part of the extra-pelvic system of fasciæ, while the sub-pubic fascia is a much more indeterminate structure, whose appearance and attachments can be made to vary by the scalpel of the dissector according to his preconceived notions. As far as it is a genuine lamella it is always continuous laterally with the fascia which covers the outside of the *levator ani*, i.e., the inner wall of the ischio-rectal fossa, and is through it continuous with the obturator fascia (§ 302). In the middle line, however, it participates in the general median fusion of structures, and can only be separated artificially.

This deeper layer and the urethra can be examined with greater advantage at a later stage in connection with the pelvic viscera (§ 302).

229. LEVATOR ANI.—The lower surface of this muscle should now be cleaned and exposed (fig. 477). It forms a boundary for the lower outlet of the pelvis, and can be seen arising from the posterior surface of the inferior ramus of the pubis opposite the lower third of the symphysis, and from the white line on the fascia, which stretches backwards from thence to the spine of the ischium

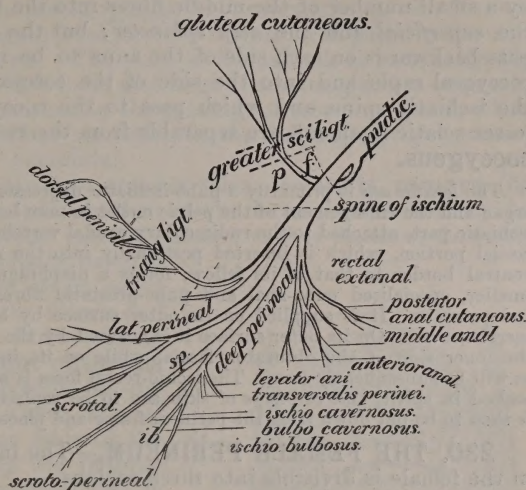


Fig. 482.—Diagram of course and branches of pudic nerve.

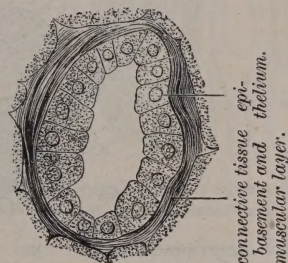


Fig. 483.—Section through acinus of Cowper's gland.

along the upper angle of the ischio-rectal fossa. Its fibres pass backwards and inwards, converging towards those of the opposite side, and are inserted by a very few of the foremost fibres around the anterior extremity of the prostate, by a small number of the middle fibres into the border of the rectum between the *superficial* and the *deep sphincter*; but the largest number of the fascicles pass backwards on each side of the anus to be inserted behind it into the ano-coccygeal raphe and into the side of the coccyx. The fibres which arise from the ischiatic spine, and which pass to the coccyx on the ventral side of the lesser sciatic ligament, are separable from the rest of the muscle and are called **coccygeus**.

The *levator ani* is primarily a pubo-ischiatic depressor of the tail, but the atrophy of this organ and the enlargement of the pelvic outlet in man have modified the muscle. Its hinder ischiatic part, attached to the rudimentary caudal vertebrae, has become *coccygeus*; its ischio-fascial portion, which is inserted post-anally into the raphe by the approximation of its ventral border to that of its fellow, forms a diaphragm for the pelvic outlet; while the smaller, specialised pubo-anal and pubo-prostatic fibres respectively can elevate the anus and prostate. It is supplied on its outer surface by branches from the third and fourth sacral nerves. On its outer surface it is covered by the anal fascia, a lamina derived from the inner side of the obturator fascia, while on its inner it is invested by pelvic fascia, as will be subsequently seen. The ischio-rectal fossa is now to be filled with cotton wadding soaked in spirit, and the flaps of skin are to be replaced and sewn over them. The body is then to be put down from the perineal frame and placed on its face for further dissection.

230. THE FEMALE PERINEUM.—The inferior exit-region of the pelvis in the female is divisible into three regions—

(1) *The Anal.*—This in most respects resembles the male anal region. The orifice is placed a little farther back, the ischia are more everted, and the ischio-rectal fossæ are shallower and wider.

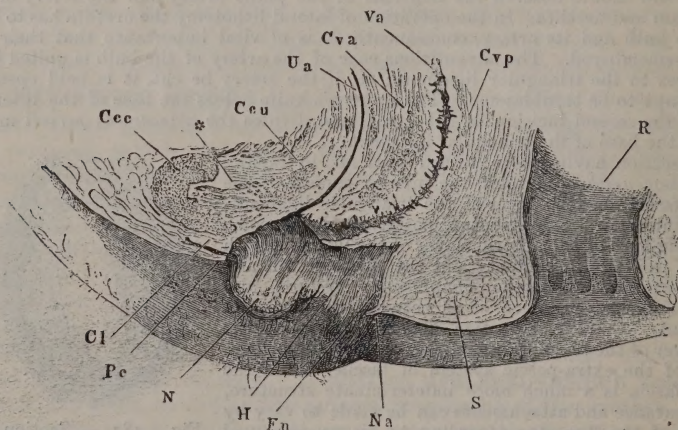


Fig. 484.—Sagittal section of female perineum—R, rectum.

Otherwise the anatomy of this region corresponds with that in the male. In dissecting this region divide the skin from the coccyx forwards in the middle line and on each side of the anal margin to its anterior border. Make also on each side two transverse incisions, one from the coccyx and the other from the front of the anus outwards to a little beyond the tubera ischii. Proceed with the deeper dissection as in the male.

(2) In front of the anus is a narrow transverse bridge of skin to which the name **perineum** is restricted by obstetricians. This is marked medially by a raphe, and the integument is tied down to a firm underlying connective tissue mass, the **perineal body** (fig. 484, S).

(3) Still farther forward is the **rima urogenitalis**, margined by the two

labia majora, which are homologous to the two halves of the scrotum, remaining persistently cleft along the *raphé* instead of uniting as they do in the male. Each of these begins as a thin fold behind, where it joins its fellow at the anterior edge of the perineum (**posterior commissure**—*ib.*, Na) and thickens forwards to where it again joins its fellow beneath the pubes in the more rounded **anterior commissure**. The skin of the labium is externally like that of the scrotum, provided with hairs and large sebaceous glands; internally is smooth, hairless, and moist, marked by the openings of sebaceous glands whose secretion contains compounds of butyric acid. In the ordinary upright position the *rima urogenitalis* is nearly horizontal.

Within the labia majora are two thinner folds, the **labia minora** (fig. 484, N). These begin on the inner surface of the former about midway between the commissures and become more prominent as they continue forwards, bifurcating as they unite medially beneath the anterior commissure. The upper larger division of each passes above the clitoris and there joins its fellow to form a fold overhanging that organ, the **præputium clitoridis** (*ib.*, Pc), the lower smaller division passing beneath the clitoris to the under side of which the two united inferior folds of the two sides are attached, forming the **frænulum clitoridis**. These labia correspond to the integument of the penis and prepuce in the male. The outer layer of these folds is modified skin, the inner is also skin nearly assimilated to mucous membrane, but the true mucous membrane begins at the inner side of the base of the labia minora. By drawing these folds aside the **clitoris** (fig. 486, Cl) can be seen. It is the homologue of the penis and consists of similar parts, but with an imperforate glans. Beneath the frænulum clitoridis in front, and the labia minora on each side, and the beginning of the vagina below, there is a triangular smooth space, the **vestibulum**, 2.7 cm. below whose apex is the round orifice of the **urethra** (*ib.*, Ou). The student should practise the passage of the catheter so as to be able to find the urethra without exposure. Within the rima, about 1 cm. in front of the posterior commissure, is a slight transverse fold of the lining membrane, the **frænulum pudendi**, the depression between which and the posterior commissure is called the **fossa navicularis** (fig. 484, Fn).

The external orifice of the vagina is a vertical slit somewhat elliptical when expanded, and is in the young subject narrowed by a thin lip-like fold, the **hymen** (fig. 484, H), very variable in form and development, projecting from its posterior and lateral margins, whose concave edge looks forwards and upwards. After its rupture its torn remnants form small rough tubercles (**carunculæ myrtiformes**), which ultimately disappear in the multipara.

The inner margins of the labia majora should be sewed together, and the skin should be divided along the edge of the rima and from the anterior commissure outwards. Reflect outwards this flap for about 10 cm. Above the anterior commissure the pubic hair-clad integument is raised on a thick fatty mass of superficial fascia, and makes an eminence, the *mons Veneris*. The superficial fascia is like that in the male, but has only a very little

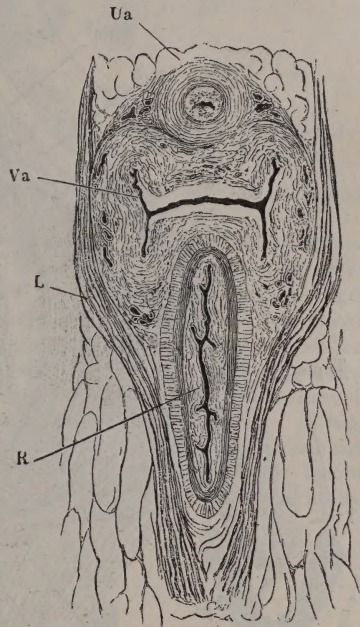


Fig. 485.—Coronal section above female perineum—L, levator ani.

involuntary muscle and so does not make a continuous dartos layer; along the margin of the labia it becomes united to the deep fascia, which is, however, very feebly developed, covering the perineal muscles. Tracing the superficial fascia towards the abdomen on each side, the end of the round ligament of the uterus can be found, around which is a prolongation of the deep fascia of the abdomen which may be dilated into a pouch, the **vulvo-serotal sac**. The long pudendal nerve is distributed in the superficial fascia of the labium, together with the terminal filaments of the anterior superficial perineal nerve and the branches of the long perineal artery, and posteriorly in the perineum the transverse perineal artery, which can be shown in their continuity by reflecting outwards the skin from the true perineum.

Remove the weak deep fascia and the following muscles are exposed on each side:—

(1) **Transversus perinei** (fig. 486, Tps), very feeble and usually divided into several fasciculi, which pass as in the male from the ischium inwards behind the posterior commissure to the central perineal point.

(2) **Ischio-cavernosus**, similar to, but much smaller than the corresponding muscle of the male, and sheathing the corpus cavernosum clitoridis (*ib.*, Ic and Ic¹).

(3) **Sphincter vaginae** (*ib.*, Bc¹, Bc², Bc³), consisting of fibres arising from the centre perineal point behind the vagina, and usually connected with the deep fibres of the *superficial sphincter ani*. The fibres pass on each side of the vaginal orifice to unite in front by being attached to the sides of the corpora cavernosa clitoridis, and to the submucous tissue of the vestibulum. This corresponds to the *bulbo-cavernosus* of the male, and overlies on each side an

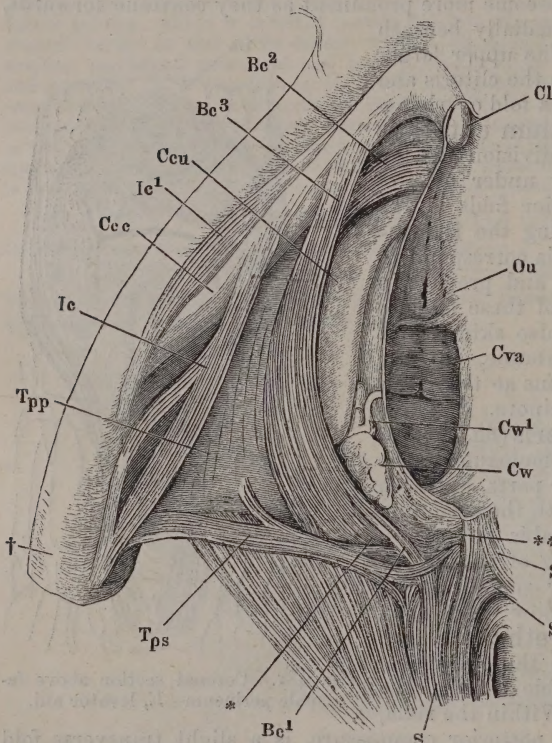


Fig. 486.—Muscles of female perineum.

erectile mass corresponding to the urethral bulb. If in the male the urethra be laid open from the orifice to the bulb, the comparison of the different parts with those in the female will be facilitated.

These three muscles bound a triangle as in the male, but one of much smaller size. They should be removed to see the erectile tissues underlying, which are (1) the vaginal bulbs (fig. 486, Cu) and (2) the corpora cavernosa (*ib.*, Ccc). The **vaginal bulbs** are two oblong masses, invested by a fine fibrous envelope on each side of the opening of the vagina and vestibule. They are narrow and medially coalescent anteriorly, in front of the urethra, wide and divergent behind; convex externally and covered by the *sphincter vaginae*, concave internally and lined by the mucous membrane of the vagina. The

anterior, pre-urethral part (*pars intermedia*) contains a large venous plexus, and is continued upwards into the angle between the crura clitoridis and thence into the *glans* which is its anterior extremity, and which structurally resembles that of the penis.

The *corpora cavernosa* on each side resemble on a small scale those of

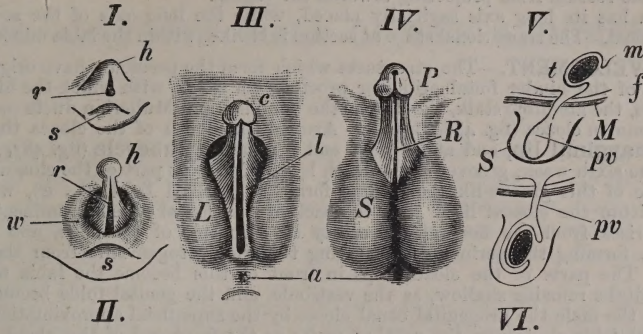


Fig. 487.—Diagram of development of external structures of perineum—s, rudimental tail; III., formation of vulva in female; IV., closure of urethra in male; for V., VI., see § 245.

the penis, and the suspensory ligaments and dorsal vessels are also similar but diminutive.

When the corpus cavernosum clitoridis is detached from the tuber cavernosum, a deeply placed triangular ligament (*ib.*, Tpp) is brought into view attached laterally to the ischio-pubic ramus, medially to the vaginal wall behind the bulbus vaginæ, above to the sub-pubic ligament, behind to the deep perineal fascia and to the *perineal body*. The ligament is much weaker, but much wider than that in the male, and is pierced by comparable parts. The orifices of the urethra and the vagina in the triangular ligament can be seen, on the removal of the bulb, to be separated by a very narrow shred of fibrous tissue. It has behind it the pudic and perineal nerves and the pudic vessels. The attachment of the base of this layer to that of the contiguous portion of pelvic fascia (§ 302), or the deep layer of the triangular ligament, is closer than in the male.

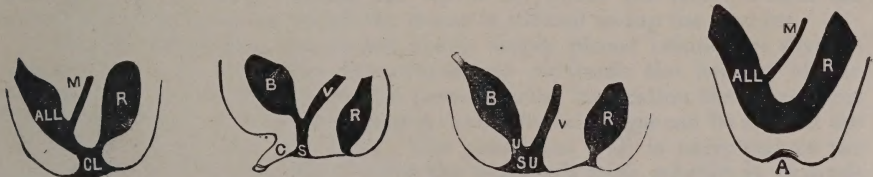


Fig. 488.—Diagram of vertical section through lower end of embryo, showing the process of differentiation of the cloaca—A, before the communication with the proctodæum to form a cloaca, CL. The central figures are the male and female modifications.

Above this union lie two yellowish, racemose, acinous glands, resembling, but much larger than, Cowper's, and called the **glands of Bartholin** (*ib.*, Cw). Each is about 1 cm. long and 7 mm. broad, and they lie on the upper and anterior surface of the vagina, closely connected to its mucous membrane and beneath the sphincter vaginæ. The ducts (*ib.*, Cw¹) are 2 cm. long, pass obliquely forwards, and open immediately external to the hymen at the mid-point of the lateral wall of the vaginal orifice, close to the largest of the *carunculæ myrtiformes* and within the *labium minus*.

The *labia minora* are large and project beyond the *labia majora* in the foetus and in the African adult. The hymen is somewhat tubular in the foetus and child, and may even close

the orifice of the vagina. It may be crescentic, with two cornua, hippocrepian, cribriform, annular, fimbriated, bilabiate, irregular, band-like, cordate, projecting, notched, papillose, or even imperforate.

The **perineal body** (fig. 484, S) is a not very well defined pyramid of tough elastic connective tissue, about 3 cm. high by 4 cm. broad, which deflects the anus backwards and forms the central mass of the perineum, strengthening the hinder commissure of the labia, and preventing the rectum from projecting towards the vagina.

The rima has its long axis sagittally placed, while the long axis of the section of the vagina is coronal. The transitional stage of section is H-like, within the labia minora (fig. 485).

231. DEVELOPMENT.—The structures which form the perineum have originated from the margins of the hinder foetal orifice or proctodæum (§ 14), with which the hinder end of the intestines, the allantoic stalk, the ureter, the Wolffian and Müllerian ducts communicate, forming a common cloaca (fig. 488, B, CL). Around the mouth of the cloaca there forms a prominent **marginal lip**, and at its front end a **genital tubercle** (fig. 487, *h*) begins to project at the sixth week, grooved underneath by the foremost part of the cloacal cavity (*r*). On each side of this groove-like part there forms a **genital fold** (*ib.*, *w*), which passes backward within the cloacal lip. Near the back of the cloacal edge a prominent **perineal tubercle** arises from the floor of the cavity on each side of the anus, and closes over transversely, forming the perineum, separating the sinus urogenitalis from the anus (fig. 488, S, R). The parts of the cloacal lips in front of this become the labia majora; the sinus urogenitalis remains shallow, as the vestibule, and the genital folds become the labia minora. In the male the urogenital canal closes by the superficial approximation and union of the genital folds closing on the urethra as far as the front end of the glans, and by the fusion of the labia majora or cloacal lips behind it to form the scrotum. In anomalous states the male urethra remains open at the raphé, making the deformity called **hypospadias**. The erectile tissues of the corpora cavernosa are developments in the connective tissue layers of the cloacal lip; those of the corpus spongiosum in the tissues of the vestibule (p. 363). Both are primarily bilaterally symmetrical, although from the fusion of the latter in the male the bulb and corpus spongiosum appear externally as if they were single and median.

THE ANTERIOR WALL OF THE ABDOMEN.

232. SURFACE MARKINGS.—The abdominal wall extends from the lower edge of the ribs, which bound it above, to the crest of the ilium, fold of the groin, and pubes, below. Its superficial appearances vary with age, muscularity, and fatness. In a strong male the surface is irregular, the fleshy parts of the muscles standing out in relief, while the tendinous lines are marked as depressions.

In the middle line, on the level of the intervertebral disc between the third and fourth lumbar vertebræ, is the wrinkled cicatrix of the **umbilicus**, which in the fœtus was the opening through which the umbilical vessels passed.

The umbilicus at birth is a little below the mid-point of the stature; at two years it is at the mid-point; but after thirty months it becomes well above the mid-point of the body, which in the average adult man is 1 cm. below the crest of the pubes, in the adult woman is 1·5 cm. above the pubes.

The *median abdominal furrow* extends from the umbilicus up to the sternum and downwards halfway to the pubis. On each side of this the *rectus abdominis* muscle bulges, and outside this is a second groove, the *lateral abdominal furrow*, which descends for the tenth costal cartilage, where it widens into a sort of shallow triangular fossa. When the body is bent forwards during life transverse folds divide the ridge formed by the *rectus* muscle. One of these transverse lines is at the umbilicus, one midway between it and the eighth rib cartilage, and one at that cartilage; these correspond to tendinous intersections in the muscle, and are very conspicuous on the abdomen of an athlete. When there is much subcutaneous fat the skin usually presents two transverse folds on flexion, one at the umbilicus and one below it; where the latter crosses the median line is the point at which the trocar is entered to tap the bladder.

The ensiform cartilage can be felt above, deeply placed behind the seventh rib cartilages, and from this downwards and outwards the borders of the successive ribs can be felt. In a thin person during inspiration the zig-zag line of the indigitations of the *serratus magnus* and *external oblique* can be seen on the surfaces of the ribs (fig. 371, 8-9). The abdominal wall is narrowest at the waist, which is naturally placed below the tenth rib, from whence it expands downwards to the iliac crest. At the inner part of the fold of the groin the spermatic cord can be felt in the wall as an oblique, rounded ridge, extending obliquely downwards into the scrotum on each side of the root of the penis; and if the skin be pushed upwards and outwards along it, the tip of the finger can be projected into the superficial abdominal ring, where the abdominal wall is weakest, immediately above and external to the spine of the pubes, which is here palpable. In the median line over the pubes is a convex hair-clad eminence, the *mons pubis*, below which is the root of the penis.

The abdominal skin is sensitive, especially above; beset with hairs directed downwards and inwards, which are stronger medially and below than laterally, and in the female only developed on the pubes. These are about 18 to the sq. cm. Sebaceous glands are small and scattered, except on the pubes, and sudoriparous glands are few, about 112 to the sq. cm. After distension from pregnancy or fat the skin presents depressed white marks, *striae gravidarum*, from which papillæ and hair follicles are absent. In colour, the skin is darker

in the middle line and below, especially on the scrotum. A dark line marks the lower part of the anterior abdominal furrow during pregnancy. The skin is also dark on the body of the penis and loosely connected to the underlying parts, being prolonged anteriorly into a duplicature, the foreskin or **prepuce**, sheathing the end of the penis, to which it is below tied by a median fold, the **frænum præputii**. The median raphe of the scrotum and perineum passes backwards from this fold. The outer layer of the foreskin is continuous with, and similar to, the rest of the skin of the organ; the inner layer is thin, hairless, without sweat glands or mucous glands, and continuous around the prominent edge of the extremity of the penis, with the thin skin adherent to the end of the organ or **glans penis**. Around the margin of the glans penis (*corona glandis*) are many small sebaceous glands without rudimental hair follicles; these are called **Tyson's glands**, but the structures which are usually pointed out as Tyson's glands are really papillæ. On the skin of the glans are rows of papillæ increasing in size and converging to the urethral orifice, but buried in the thick epidermis, so that they do not project as roughnesses on the surface.

The skin of the scrotum is thin, extensile, deeply pigmented, corrugated, and hairclad, the hairs starting from large follicles and accompanied by many sebaceous glands. The scrotum is usually unsymmetrical, its left side being the lower and farther back.

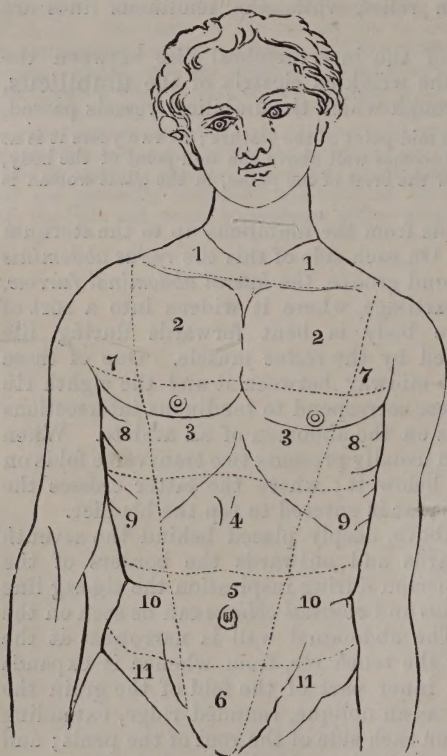


Fig. 489.—Diagram of regions of the abdomen—4, epigastric; 5, umbilical; 6, hypogastric; 9, hypochondriac; 10, lumbar; 11, inguinal. The other numbers refer to divisions of the thorax—1, supraclavicular; 2, subclavicular; 3, mammary; 7, axillary; 8, infra-axillary.

233. REGIONS OF THE ABDOMEN.—For purposes of description the abdomen may be divided into nine regions by two *transverse lines*, one drawn between the superior iliac spines and one between the cartilages of the tenth ribs, and two nearly *vertical lines* on each side drawn from the spines of the pubes to the cartilage of the eighth rib. The several regions and their contents are:—

(1) **Right hypochondriac**, under the right rib cartilages, contains the liver, gall-bladder, the hepatic flexure of the colon, and the upper part of the right kidney (fig. 489, 9);

(2) **Left hypochondriac** contains the left end of the stomach and of the pancreas, the spleen, the splenic flexure of the colon, the tail of the pancreas, and upper part of the left kidney;

(3) **Epigastric**, between these, contains the rest of the stomach, liver, and pancreas, parts of the duodenum, kidneys and suprarenal capsules, and the aorta (*ib.*, 4);

(4) **Umbilical**, below the last, contains parts of the transverse colon, great omentum, mesentery, duodenum, and small intestines (5);

(5) **The right lumbar**, to the right of the umbilical, contains the colon, part of the right kidney and small intestines (10);

(6) **The left lumbar** contains the left colon, left kidney, and parts of the small intestines;

(7) **The hypogastric**, above the pubes, contains the bladder and small intestines, and the uterus, when distended, in the female;

(8) **The right inguinal**, above the outer half of the fold of the right groin, contains the cæcum and some of the small intestines;

(9) **The left inguinal** contains the sigmoid flexure of the colon and some of the small intestines.

Dissection.—Divide the skin in the middle line from the metasternum to the pubes; carry two transverse incisions through the skin as far back as is necessary, one on the level of the umbilicus and one on that of the metasternum, and a fourth oblique incision along the fold of the groin. Reflect these flaps of skin on each side. Divide the skin along the dorsum of the penis and along the middle line of the scrotum, and dissect off the integument from one side of both parts.

234. THE SUPERFICIAL FASCIA (fig. 503) varies in thickness with the fatness of the body. Above, it is loose, areolar, with but a small amount of fat, and continuous with the superficial fascia of the thorax; below, it is thicker, firmer, more fatty, and more elastic, and continuous into the superficial fascia of the thigh. Over the pubes it becomes thick with coarse-grained fat, but becomes suddenly thin and loose and fatless on the penis, being particularly lax and capable of great stretching between the two layers of skin of the prepuce, so much so that if the skin be drawn forwards and cut off, as in unskilful circumcision, a large area of raw surface of the deep layer of the prepuce is left. An irregular layer of longitudinal elastic fibres lies between the layers of the prepuce, and is attached to the skin at the orifice of the prepuce.

Towards the scrotum the superficial fascia becomes thinner and loses its fat, developing in its substance, as it descends, much smooth muscular tissue, and it is here called the **dartos**. This forms a uniform reddish envelope for both testes, and is permeated by a dense lymphatic network. Its lamellæ are united by much elastic tissue, and a thin plane of areolar tissue is continued backwards from it medially between the two layers of the deep fascia which make the **septum scroti**. In this areolar lamella are the terminal branches of the long perineal artery. The muscular tissue is irregularly disposed, and is thicker in front and on each side where its fibres run chiefly vertically. Many sagittal fibres are scattered in the septum. Along the linea alba and along the fold of the groin the superficial fascia is traversed by fine fibrous bands, which tie it to the skin and to the subjacent deep fascia and muscle.

Three branches of the femoral artery ramify in this fascia, supplying it and the skin—(1) the **superficial pubic artery** which ascends inwards over the pubis, (2) the **superficial epigastric** which is traceable upwards and inwards as high as the umbilicus, and (3) the **superficial circumflex iliac**, which passes upwards and outwards towards the iliac crest. The commencement of each vessel is beneath the deep fascia, but its branches are distributed in the superficial layer. The vein accompanying the second of these arteries is large and often communicates with the lateral thoracic vein above.

235. THE DEEP FASCIA (fig. 503) on the abdomen (**Scarpa's fascia**) is very thin, so the removal of the superficial fascia requires much care in the dissection. The deep fascia is a plane of areolar tissue without fat, underlying the vessels, but in fat bodies often having a layer of fat beneath it. It is closely attached to the deeper parts along the middle line, and is continuous into the fascia lata of the thigh along the line of Poupart's ligament. Internally it forms a sheath around the spermatic cord almost inseparable from the deep layer of the dartos, and extends into the scrotum forming a firm areolar envelope for the testis. As this layer is pushed before the testis in its descent so there is a separate sheath for each testis in the scrotum, the two contiguous layers of which, meeting in the middle line, make the **septum scroti**. Internal to the

spermatic cord the deep fascia is continuous downwards on the upper surface of the penis, forming the superficial portion of the so-called **suspensory ligament**.

On carefully isolating this by removing the fat, it will be noticed that the fascia attached to the middle line of the abdomen above the pubes contains many elastic fibres, and these, descending on the dorsum of the penis, make a deep fascial envelope for the organ. If this be artificially separated from its lateral and deep connections it appears as a flattish expansion, whose edges are lateral and whose surfaces are directed fore and aft. To this the name *false suspensory ligament* is given. On removing this, there is seen beneath it a deeper lamella, usually of white fibres, attached behind to the median line of the symphysis pubis and in front to the dorsum of the penis, its edges being directed fore and aft and its surfaces laterally. This constitutes the *true suspensory ligament*.

The deep fascia derived therefrom which sheaths the penis is continuous backwards into the deep perineal (Colles's) fascia. Urinary extravasation, following rupture of the urethra beneath the latter, is prevented from passing backwards by the reflection of the fascia around the *transversus perinei* muscle, but ascends here by the root of the penis to the groin and so enters the scrotum, ascending also beneath the deep fascia on the abdominal wall. The attachment of the latter to Poupart's ligament prevents the extravasated urine from passing down the thigh.

In removing the deep fascia two rows of nerves are found emerging from the abdominal muscles and piercing the fascia to reach the skin. On each side of the middle line above the umbilicus, fine *anterior cutaneous* branches of the eighth, ninth, tenth, and eleventh intercostal nerves escape and pass outwards to the integument. Below the umbilicus two branches of the **hypogastric nerve** pierce the fascia about 5 cm. from the middle line and 10 cm. above the pubis. Below and outside the spermatic cord the **ilio-inguinal nerve** pierces the muscles to ramify below in the skin of the scrotum.

Lateral cutaneous nerves from the seventh to the eleventh intercostal nerves escape along each side; the seventh and eighth make their exit between the

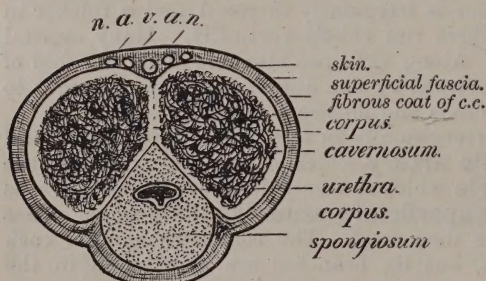


Fig. 490.—Transverse section across the middle third of the body of penis.

serratus magnus and *external oblique*, the lower three pierce the *oblique* muscle, and each divides into a small posterior, and a large anterior branch which supply the skin. The lateral cutaneous branch of the subcostal nerve has no posterior branch, it pierces the oblique below the front end of the eleventh rib, crosses the iliac crest 5 cm. behind the superior spine, to supply the skin of the gluteal region. A lateral cutaneous branch of the first lumbar

nerve runs parallel to and behind it, crossing the mid part of the iliac crest. Small vessels accompany these nerves from the epigastric and intercostal respectively.

Between the lamellæ of the true suspensory ligament are the penial vessels and nerves. The *dorsal arteries* (fig. 490, a) are the terminal branches of the pudics (§ 226), and are distributed on each side of the middle line to the integument and glans. The *dorsal nerves* (*ib.*, n) lie outside the arteries and supply the skin, ending in the papillæ of the glans. The *dorsal vein* (*ib.*, v) is single, median, and begins by branches from the glans and prepuce, passes backwards in a median sulcus between the two arteries, receiving branches from

the corpora cavernosa. It pierces the triangular ligament and enters the pelvis to join the intrapelvic system of veins.

236. THE PENIS consists of three parts—a **corpus spongiosum urethræ** medially and below, and on each side a **corpus cavernosum**. Each of the latter arises by a narrow hinder end, the **crus penis**, from the tuber cavernosum, to which it is fastened by strong fibrous tissue, as has been seen in the dissection of the perineum: passing forwards, it comes in contact with its fellow in front of the scrotum and forms thereby the *body of the penis*. The two corpora cavernosa can be partially separated above and behind beneath the dorsal vein, but anteriorly they are inseparable, and each ends in a blunt rounded extremity, over which the anterior end of the corpus spongiosum urethræ (*glans penis*) is expanded as a cap. The corpus spongiosum has already been seen beginning behind in the bulb of the urethra, and can now be seen ending anteriorly in the glans, whose prominent hinder margin is the *corona glandis*.

The *urethra* opens between two lobes of the lower border of the glans by a vertical slit, the *meatus urinarius*.

Each corpus cavernosum consists of erectile tissue (§ 52, fig. 139). It is invested by a strong fibrous capsule composed of interlacing bands of white fibrillar tissue, which for that portion of the organ in which the two corpora are side by side, makes a perforated septum, mostly of strong vertical fibres, the **septum pectiniforme**, incomplete anteriorly. The lower border of this septum is strengthened by isolated spots of denser fibrous tissue, representing the *os penis* of so many animals. I have failed to find any trace of ossification or fibro-cartilage in the septum of any individual of any race. From this fibrous investment a system of septa and bands of white and yellow tissue pass inwards into the substance of the corpus cavernosum, making a spongy basis of fibrous tissue for the whole thickness of the corpora cavernosa, the gaps between which form a system of venous spaces, filled with blood and lined by endothelium. The largest of these sinuses are below and external in the *corpus cavernosum*. The branches of the artery of the corpus cavernosum (the *helicine arteries*) pass in very sinuous courses, and terminate in the capillaries which directly communicate with the sinuses. Veins arise by venous capillaries from these sinuses, which unite into trunks that pass to the dorsum of the penis and form the radicles of the dorsal vein, and as these channels traverse the meshes of the vascular network on their way to the surface, the blood in these meshes serves to compress the outgoing venous trunks, and so to produce and maintain turgescence, increasing the bulk of the organ about five times. The nervous supply of these vessels consists of fibres coming through the hypogastric plexus from the second and third sacral nerves. These nerves contain many vasodilator fibres, and in the preliminary stage of turgescence they cause dilatation of the arteries, allowing thereby an increased flow of blood.

The examination of the corpora spongiosa should be postponed until the urethra is being dissected, so the penis should be wrapped in a wet cloth and covered with waterproof in the meantime. Raise the deep fascia from the subjacent *external oblique* muscle and tendon, and as the sheath of the muscle is closely adherent at its margin to the latter, care must be taken not to remove the tendon with it.

237. THE EXTERNAL OBLIQUE (fig. 492, 4), the largest of the parietal muscles of the abdomen, arises by fleshy slips from the outer surfaces of the seven lower ribs, the last slip surrounding the extremity of the twelfth rib.

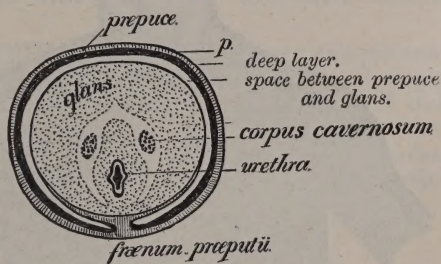


Fig. 491.—Section through the glans penis.

The inferior three indigitate with the costal origins of the *latissimus dorsi* (*ib.*, 2); the upper four with the *serratus magnus* (*ib.*, 3). The origin from the ninth rib is generally the largest, and the indigitations diminish gradually above and below. The fibres run in a continuous sheet downwards and forwards, but with varying obliquity; the hindmost form a free border, bounding *Petit's triangle* (§ 144, fig. 353), and descend nearly vertically to the mid-point of the outer lip of the crest of the ilium, while the uppermost fibres (fig. 492, 5), which are aponeurotic for most of their extent and form an exceedingly thin sheet that craves wary dissection, run nearly horizontally. The fibres from the eleventh and twelfth ribs are fleshy for their whole extent, and are inserted into the anterior half of

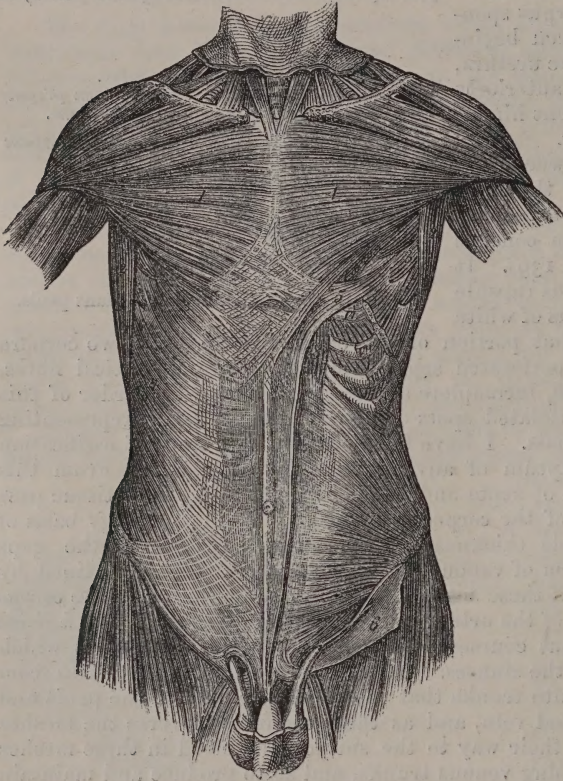


Fig. 492.—The external and internal oblique muscles of the abdomen.

vessels. It is medially interrupted by the umbilicus, through which in the adult a small mass of cicatricial tissue projects, representing the ends of the foetal vessels which originally traversed it.

(2) *Linea semilunaris* is a curved line, concave inwards, extending from the cartilage of the eighth rib to the pubes, marking the outer edge of the *rectus abdominis* muscle.

(3) *Lineæ transversæ* are white depressed lines joining together the former pair, one placed at the level of the umbilicus, one opposite the tenth rib cartilage, and one at the seventh rib cartilage. These mark the lines of tendinous intersection of the *rectus* here attached to the overlying tendons (fig. 494).

the iliac crest; those from the tenth rib become tendinous anteriorly, and form by their insertion the tendinous band which stretches from the superior iliac to the pubic spine (*Poupart's ligament*—§ 105, fig. 261); those from the seventh to the ninth ribs become tendinous opposite a sinuous line drawn from the eighth rib to the front of the crest, and the aponeurotic expansion thus formed is medially inserted into the *linea alba*. The aponeurosis is narrowest at the umbilicus, broadest between the superior iliac spines.

The surface of the external oblique tendon shows the following appearances:—

(1) *Linea alba*, the median fusion of the tendons of the abdominal muscles, extends from the metasternum to the pubes as a depressed white line, narrow below, wider above, crossed by no muscular fibres and by few

(4) **Ventral foramina** are small holes for the exit of the anterior cutaneous nerves and vessels.

(5) **Poupart's ligament** (fig. 261) is the inferior edge of the tendon stretched from the superior iliac spine to the pubic spine and attached by its hinder surface to the deep abdominal fascia, and by its lower edge to the fascia lata of the thigh (fig. 503, *a*). It is curved convexly downwards while undisturbed, but when it is detached from the fascia lata it becomes straight. When thus dissected and its under side exposed, the ligament appears to have its lower edge turned inwards so as to make its upper and inner surface (which cannot yet be seen) somewhat gutter-shaped. The insertion is widened and prolonged outwards along the ilio-pectineal line for about 2 cm., forming a triangular expansion (**Gimbernath's ligament**), with a concave free outer border directed towards the femoral vessels.

238. THE SUPERFICIAL ABDOMINAL RING is the very oblique and somewhat triangular opening in the tendon of the *external oblique* through which the spermatic cord passes in the male, and the round ligament of the uterus in the female. It is formed by the separation of two fascicles of the tendon of that muscle, that which forms the pubic end of Poupart's ligament being its **outer pillar** or boundary, and that which is inserted into the pubic

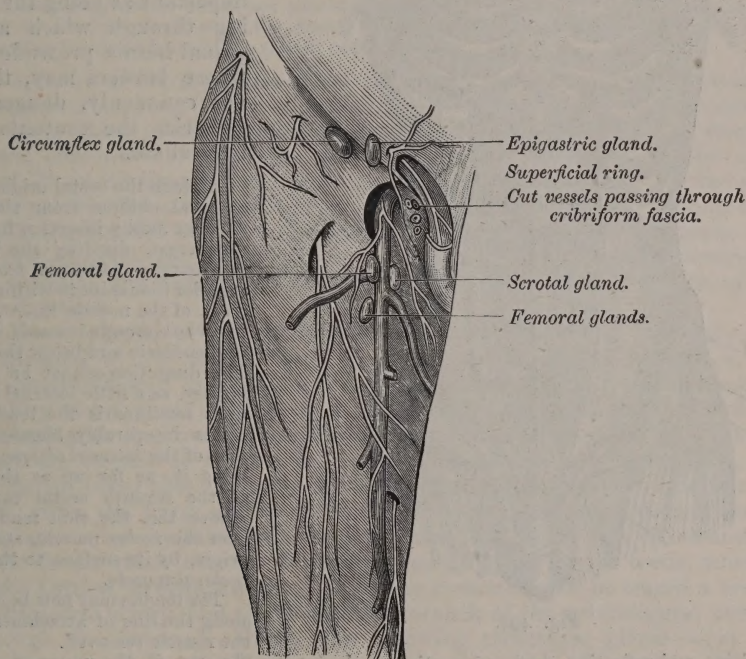


Fig. 493.—Superficial or external abdominal ring.

crest forming its weaker **inner pillar** or boundary. The base is at the pubis, while its apex is at the point of divergence of the pillars above and externally. The centre of the opening is about 5 mm. above the spine of the pubis.

The borders of the opening are not clearly defined until an expansion, which is prolonged from them over the parts which pass through the ring, is divided. This **spermatic fascia** is a membrane attached to the surface of each pillar of the ring, and traceable downwards as an envelope of the spermatic

cord into the scrotum. By lifting and gently pulling the cord this expansion can be made tense, and by dividing it along its attachments to the pillars of the ring the opening may be made artificially definite. When thus made distinct, the ring in the male is usually about 3 cm. long by 1 cm. broad, and in the female about half this size. A stratum of white fibres which run upwards and inwards is expanded over the whole tendon of the external oblique whose fascicles its fibres cross at an angle. A very strong series of these **intercolumnar fibres** arises from the outer third of Poupart's ligament, and, as they cross the external oblique tendon above the apex of the external abdominal ring, they prevent the undue divarication of the pillars of the ring. The

spermatic fascia which forms a sheath for the cord is an expansion downwards of this layer. The ilio-inguinal nerve (§ 314) pierces this expansion below the spermatic cord on its way to the skin of the scrotum. The superficial abdominal ring is important as being the opening through which an inguinal hernia protrudes, and whose borders may, though not commonly, dangerously constrict the contents of a hernial sac.

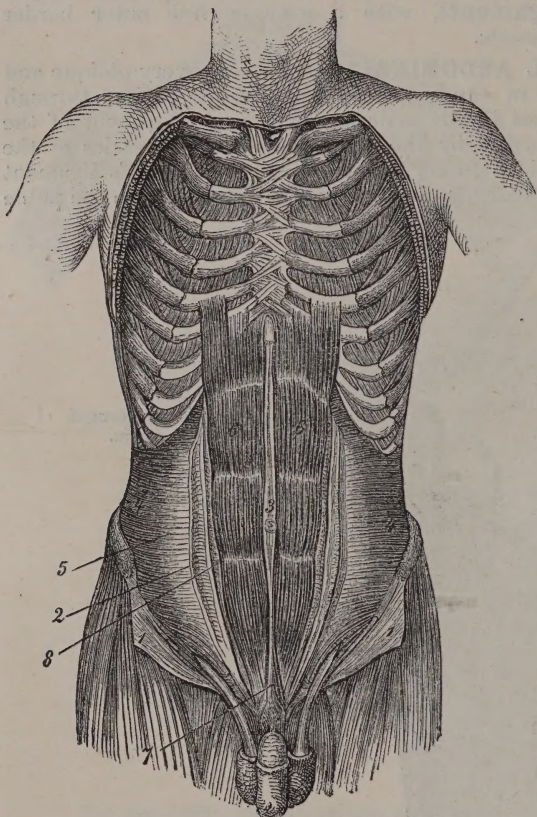


Fig. 494.

Raising and reflecting the lower portion of the tendon (fig. 492, 6), the upper or grooved surface of Poupart's ligament is brought into view.

From its pubic attachment there is a thin expansion reflected upwards and inwards to the middle line (the **triangular fascia**) underlying the internal pillar of the external abdominal ring and overlying the internal oblique tendon. Its fibres are not traceable across the median line. It is usually stronger in males than females, and is very weak in the presence of a *pyramidalis* muscle, of whose sheath it is a specialised portion.

Some of the tendinous fibres of the internal pillar of the ring are attached to the pubis, some cross the median line to be attached into the fascia lata of the opposite thigh, and some descend into the true suspensory ligament of the penis.

The *external oblique* is the abdominal representative of the external layer of somatic muscles (§ 46, fig. 129); the next muscle, the *internal oblique* represents the internal layer;

Detach the costal origin of the external oblique from the ribs, and the fleshy insertion from the iliac crest, dividing the tendon horizontally forwards from the superior iliac spine to within about 6 cm. of the middle line. Reflect the whole muscle inwards, leaving the tendon in situ below this level. This dissection cannot be carried farther, as a little internal to the linea semilunaris the tendon becomes inseparably blended with that of the *internal oblique* underlying it, as far up as the level of the seventh costal cartilage. Above this the thin tendon lies over the *rectus* muscle, and gives origin, by its surface, to the *great pectoral* muscle.

The tendon may now be divided along the line of attachment and the muscle removed.

the third or *transversalis*, belongs to the deeper visceral plane. The *rectus abdominis* is a median specialised segmentation of the second stratum.

239. THE INTERNAL OBLIQUE (fig. 492, 7) is exposed by removing the areolar layer which sheathes its surface beneath the *external oblique*. It arises fleshily from the outer half of the upper surface of Poupart's ligament from the middle area of the iliac crest as far back as the level of the superior gluteal line, and from the lumbar fascia above and behind that level. From these origins the fibres radiate as a continuous sheet; those from the lumbar fascia ascending to the two lowest ribs. The iliac fibres, which are very thick at the anterior fourth of that crest, diverge as they ascend, and are inserted in three series, those which form the hinder third of the iliac origin are inserted into the lower borders of the cartilages of the tenth, ninth, eighth, and seventh ribs, on the same plane, and often continuously with, the *internal intercostal* muscles; those forming the middle third of the iliac origin, very thick at their origin, diverge the most and become tendinous along the upper two-thirds of the *linea semilunaris*. The tendon divides into two layers—one, an anterior lamina, passes in front, the second or posterior passing behind the *rectus abdominis*, for which they form a sheath, the two layers uniting internally at the *linea alba*.

These sheathing fibres, which are subsequently to be dissected, can be partially seen at this stage by dividing the front of the sheath between the first and second transverse lines, and reflecting the front layer of the sheath outwards.

The anterior or third portion of the iliac origin is thinner, and is continuous with the portion arising from Poupart's ligament. Its fibres become tendinous at the lower third of the *semilunar line*, but the tendon passes in front of the *rectus abdominis* to the *linea alba*. The fibres arising from the outer fourth of Poupart's ligament run downwards and inwards, and are for the most part inseparable from the contiguous part of the *transversalis* muscle, their tendons being blended here into the **conjoined tendon**. The spermatic cord lies at first beneath the lower edge of this muscle, but as it passes inwards to escape through the external abdominal ring it overlaps the border of the conjoined tendon.

The lowest portion of the muscle arising from about 3 cm. of Poupart's ligament, external to the point where the spermatic cord first lies on it, has become elongated, and is carried down by the parts which have traversed the ring during the descent of the testis, as a series of looped fibres, to which the name **cremaster** is given. These fibres descend beneath the external spermatic fascia on the outside of the cord, loop at different levels in front of it, and ascend on its inner side. Some few can be traced into the scrotum, but the majority cross the front of the cord. The loops are usually discontinuous, but they are united by interstitial areolar tissue, and with this tissue and the spermatic fascia which invests them, they make a tunic for the testis, which is called the **tunica cremasterica**. Into the cremaster can be traced a branch of the epigastric artery, and the cremasteric branch of the genito-crural nerve.

Through the internal oblique, the following structures pierce:—(1) The gluteal branch of the ilio-hypogastric nerve, over the iliac crest; (2) the hypogastric branch of the same nerve, between the superior iliac spine and the edge of the rectus; (3) the ilio-inguinal nerve, above Poupart's ligament.

Detach the internal oblique along the iliac crest, cutting through it until the underlying connective tissue containing the deep circumflex iliac artery is reached; divide the muscle vertically between the iliac crest and last rib, and cut through each costal attachment, reflect the muscle inwards towards the rectus. The origin from Poupart's ligament is also to be divided, and the lower fibres reflected inwards. When the nature of this muscle has been thoroughly appreciated, it may be cut away by a vertical incision along the *linea semilunaris*.

Upon the subjacent surface of the *transversalis* there are to be traced from above downwards the anterior continuations of the seventh to the eleventh intercostal, the subcostal,

ilio-hypogastric and ilio-inguinal nerves, with their accompanying vessels. Of these, all but the last pair pass forwards, giving off lateral cutaneous, lateral muscular, and anterior cutaneous branches, and supplying the *rectus abdominis*. The ilio-hypogastric gives off a lateral cutaneous branch, but neither it nor the ilio-inguinal supply muscles by their anterior branches.

240. TRANSVERSALIS (fig. 494, 4), beneath the last, arises fleshily by

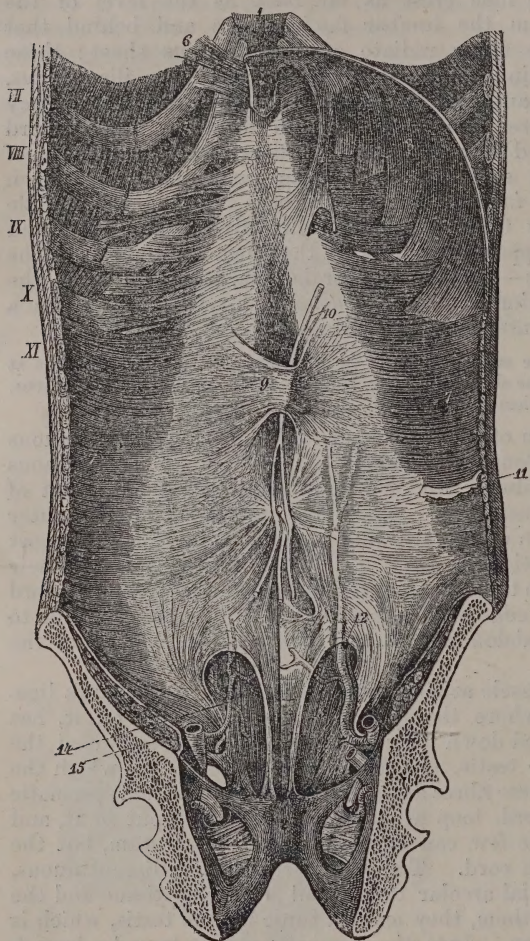


Fig. 495.—Transversalis muscle seen from behind, the peritoneum and the abdominal fascia being divided—1, sternum; 6, triangularis sterni; 9, deep band of transversalis bounding Richet's canal for 10, the umbilical vein; 12, Douglas's fold; 13, hinder surface of rectus on which the deep epigastric artery is seen to ascend (14); 15, iliacus muscle, cut.

Divide the sheath of the rectus by a vertical incision about 2 cm. external to the linea alba, and reflect the anterior wall of the sheath outwards. Along each linea transversa the sheath is adherent to the muscle, and requires to be dissected off artificially. The terminal cutaneous branches of the intercostal nerves which enter the *rectus* externally can now be seen emerging from it anteriorly to pass to the skin.

241. RECTUS ABDOMINIS (fig. 494, 6) is a quadrigastric muscle arising

by six slips from the inner surfaces of the six lower costal cartilages indigitating with the diaphragm (fig. 495, 3), tendinously from the *lateral intermuscular septum* (fig. 129), where it joins the fascia lumborum (p. 71), and by fleshy and tendinous fascicles from a little more than the anterior half of the inner lip of the iliac crest. The short fleshy fascicles run transversely and become tendinous (fig. 494, 5), before they reach the semilunar line, for the upper two-thirds of which they pass behind the rectus, fusing with the posterior layer of the tendon of the *internal oblique* (ib., 2), to be inserted with it into the linea alba (ib., 3). For about the lower third of the linea semilunaris the *transversalis* tendon passes in front of the rectus muscle along with the whole of this portion of the *internal oblique* tendon. At its lower border it joins with the *internal oblique* to form the conjoined tendon, which is inserted into the inner 3 cms. of the iliopectineal line and the crest of the pubis, where it fuses with the triangular ligament.

A very small band of the tendon of *transversalis* always descends a little lower, and lies farther outwards than the lower edge of the *internal oblique*, and is known as the **reflected tendon** of Sir A. Cooper. It passes behind the spermatic cord, as it descends underneath the lower edge of the *internal oblique* muscle.

from the crest of the pubis by a sometimes divided tendinous head. The muscle expands as it ascends, is crossed by a tendinous intersection at each linea transversa, and is finally inserted by three wide fleshy slips into the fronts of the fifth, sixth, and seventh costal cartilages.

The *rectus* is a metamerised vertical muscle whose several bellies retain their separate innervation—the lowest or infra-umbilical is supplied by the twelfth dorsal nerve, the second by the eleventh and tenth, the third by the ninth, and the fourth by the seventh and eighth intercostal nerves. Fibres of the *pectoralis major* arise from the front of its sheath (fig. 492), which, where it overlies the ribs above, consists of the external oblique tendon only in front, and the rib cartilages behind; for the upper two-thirds of the abdominal wall it consists of the tendon of the *external oblique* and the anterior half of that of the *internal oblique* in front; and of the *transversalis* and the posterior half of the *internal oblique* tendon behind. For the lower third of the abdomen the *rectus* has the entire of the tendons of the *external* and *internal oblique* muscles and of the *transversalis* in front, and lies upon the deep abdominal fasciæ behind.

On dividing part of the *rectus* vertically through a linea transversa it is to be seen that all the fibres are not tendinously interrupted, but that some posterior fibres pass from one belly to another, and also that the sheath and the muscle are not as closely connected behind as in front at the lineæ tranversæ.

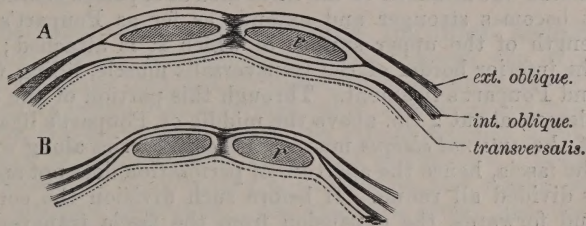


Fig. 496.—Diagram of sections of the sheath of the rectus; A, above Douglas's fold, showing the splitting of the internal oblique tendon; B, sheath below Douglas's fold, showing the formation of the conjoined tendon in front of the rectus.

Divide the *rectus* muscle at the umbilicus, and reflect its lower portion downwards. The edge at which the posterior wall of its sheath terminates now appears as a crescentic border—the *plica semilunaris* (or Douglas's fold)—placed between the umbilicus and pubis one-fourth the distance from the former, three-fourths from the latter.

Very often a part of the *transversalis* continues to send fibres behind the *rectus* for some distance below Douglas's fold, which then does not appear as distinct as in the rarer cases when no tendinous fibres extend below it. The space below the semilunar line corresponded to the area of original contact of the bladder with the foetal abdominal wall, although they have ceased to correspond long before birth. Morphologically the *internal oblique* and *transversalis* muscle end at the outer edge of the *rectus*; but the fibres of these muscles, being attached to what was primitively the perimysium of the *rectus*, have caused parts of that sheath to specialise, and to appear as inward continuations of these tendons.

Ascending in the sheath of the *rectus* behind the muscle is the deep epigastric artery (§ 289), and descending above is the superior epigastric branch of the internal mammary artery (§ 428).

242. PYRAMIDALIS (fig. 494, 7).—Internal and on a plane superficial to the *rectus*, in about 42 per cent. of bodies, lies a small triangular muscle arising from the pubic crest in front of the tendon of the *rectus*. Its fibres ascend, converging to be inserted into the linea alba at a point between the pubis and the umbilicus.

This muscle, largely developed in animals with a marsupial bone, is, in man, always of small size and sometimes unilateral.

The actions of the several abdominal muscles are easily understood from the course of their fibres. Acting together, they compress the abdomen, evacuate the cavities, and forcing up the diaphragm act as extraordinary muscles of expiration.

Reflex action of these muscles may be excited by stimulating the skin along the lateral cutaneous nerves.

When all muscles of the two sides have been thus dissected, the linea alba, which now appears as a substantive structure, may be examined (fig. 494, 3). It will be noted that it is thinner and wider above, and is attached to the ends of the cartilages of the seventh

ribs as well as to the sides of the metasternum; below it is narrower and deeper, and it is stronger at the umbilicus than elsewhere. At its lower end it contains some vertical fibres, and these expand below, behind the recti, and are attached by a widening expansion to the upper surface of the pubic crest. This fixed end of the linea alba is called the *adminiculum lineæ albae*.

243. FASCIA TRANSVERSALIS is exposed by dividing the *transversalis* muscle vertically from the superior iliac spine to the eighth rib cartilage and reflecting the muscle backwards and forwards. This layer is thin above, becoming continuous with the infra-diaphragmatic fascia, but becomes thicker below. It is closely tied to the deep surface of the *transversalis* muscle where it is fleshy, but is easily separable from its tendon, and is continuous from side to side but attached to the linea alba as it passes behind it. Traced downwards, it becomes stronger and extends as far as Poupart's ligament, to the whole length of the upper surface of which it is attached; and so it appears below the inferior border of the transversalis muscle, filling the interspace between it and Poupart's ligament. Through this portion of the fascia the spermatic cord pierces, about 2 cm. above the middle of Poupart's ligament, but, as in the case of the *external oblique* muscle, the cord carries along with it an expansion from the fascia, hence the aperture of perforation does not appear until this expansion is divided all round. If before such division the cord be drawn downwards and forwards, the expansion from the fascia transversalis (**infundibuliform fascia**, fig. 497, 16), can be seen as a distinct sheath on the cord; by cutting

this around the cord an opening in the fascia transversalis (the **deep abdominal ring**) is made. It is to be noted that this ring, which is sometimes called *internal*, lies external, i.e., farther from the middle line than the superficial or so-called external abdominal ring.

This opening, as such, is purely artificial, but forms the starting-point of the **inguinal canal**, by which name is distinguished the space traversed by the spermatic cord (fig. 497, 17), or round ligament between the deep and the superficial rings. This canal is an oblique passage running downwards and inwards from the deep to the superficial ring, and is about 6 cm. long. Below it is bounded by the upper or grooved surface of Poupart's ligament and the portion of Gimbernat's ligament attached thereto; anteriorly it is covered by the expanded tendon of the *external oblique* and (at its outer part) the lower edge of the *internal oblique* muscle; above is the

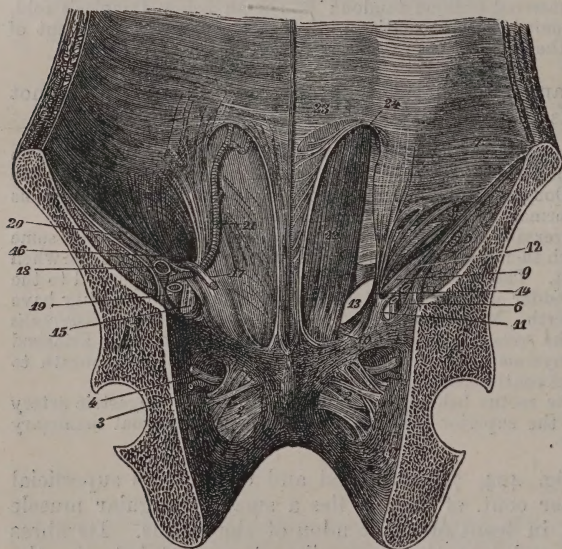


Fig. 497.—View of fascia transversalis and deep part of abdominal wall from within, showing internal abdominal ring—2, obturator membrane; 3, 4, obturator artery and nerve; 6, ilio-pubic ligament; 9, cremaster; 10, pubis, superior ramus; 11, Gimbernat's ligament, the space external to which is the femoral ring, seen on the other side at 15; 12, Poupart's ligament; 13, deep view of superficial abdominal ring; 14, outer pillar of ring; 18, 19, external iliac artery, and vein.

teriorly it is covered by the expanded tendon of the *external oblique* and (at its outer part) the lower edge of the *internal oblique* muscle; above is the

lower edge of the *transversalis* muscle. The posterior wall consists of (1) fascia transversalis, behind which ascends (2) the epigastric artery, (3) the margin of the reflected tendon of the *transversalis* when distinct, (4) the conjoined tendon, and (5) the outer edge of the triangular fascia.

The relation of the epigastric artery (fig. 497, 21) to this canal is of great importance. It can be felt through the fascia transversalis ascending behind the spermatic cord close to the internal border of the deep abdominal ring, and hence on a plane external to the superficial ring.

It is a good plan to divide on one side the fascia transversalis at the level of the superior iliac spine, and to separate it from the subjacent layer so as to get a view of the deep abdominal ring from the inner side. The opening in this position when the cord is drawn down appears as a narrow fissure (fig. 497, 16).

The form of intestinal protrusion called **oblique inguinal hernia** traverses the inguinal canal, leaving the abdominal cavity through the deep ring, descending along the spermatic cord, and projecting through the superficial ring. Such a hernia will carry before it as coverings—skin, superficial and deep fasciæ, the spermatic fascia, the cremasteric fascia, the infundibuliform fascia, as well as the deeper layer of subperitoneal tissue and peritoneum. These layers, however, become united by the pressure of the hernia, and cannot be individualised except by artificial separation. The epigastric artery lies close to the *internal side* of the neck of an oblique hernia.

In some cases a hernia projects through the abdominal wall internal to the epigastric artery, and therefore does not traverse the deep abdominal ring; but, bursting through the conjoined tendon internal to it, enters the inguinal canal, from which it escapes by the superficial abdominal ring. Such a hernia is called a **direct inguinal hernia**, and the deep epigastric artery lies to the *external side* of its neck.

The infundibuliform fascia can be traced as an envelope of the spermatic cord downwards into the scrotum. Between it and the overlying cremasteric fascia lie the branches of the genito-crural nerve and the cremasteric branch of the epigastric artery, just as outside the cremasteric and spermatic fasciæ lie the scrotal branches of the ilio-inguinal nerves. Within the infundibuliform fascia are to be found the vas deferens or duct of the testis, distinguishable by its hard, cord-like feel, the spermatic artery a branch from the aorta, the spermatic plexus of veins, the spermatic plexus of nerves, and an areolar layer—the degenerated serous envelope of the cord.

244. SCROTUM.—The skin, dartos, and deep fascia have been already removed from the scrotum. Beneath these, the three subjacent layers of spermatic, cremasteric, and infundibuliform fasciæ, are so closely united as to be with difficulty separable from each other. The layer thus made has been called **tunica cremasterica** (fig. 498).

The vessels of the scrotum hitherto observed have been derived from two sources. The cutaneous structures are supplied by vessels from contiguous regions, the two pubic branches of the femoral (superficial and deep) and the superficial perineal. The deep parts which have descended from the abdominal cavity receive their supply through the three arteries in the spermatic cord, the parts derived from the deep portion of the abdominal wall, such as the cremaster, being supplied by a branch of the epigastric (§ 289), the vas deferens by a branch of the vesical (§ 283), and the testis by the spermatic (§ 276).

The nerves are similarly in two sets, the cutaneous being those from the perineal, from the long pudendal branch of the small sciatic, and the ilio-inguinal. The cremaster is supplied by the genito-crural, and the deeper parts by the nerves of the spermatic plexus.

These supplies are correlated with the threefold sources of the parts.

Having removed these layers—skin, dartos, and tunica muscosa—the outside of the **tunica vaginalis** or serous envelope of the testis is exposed. This was originally continuous with the peritoneum, but becomes isolated in early life (fig. 84); a trace of the connection remaining often as an indefinite areolar string in the substance of the spermatic cord. The outer surface of the tunica vaginalis is rough and areolar. On slitting open the sac in front of one testis from above downwards, its visceral portion appears closely adherent to the front and sides of the testis. The parietal portion is wider, lining the scrotum, extending both above and below the gland, and forming a narrow pouch (**digital fossa**—fig. 498) along the external posterior edge of the gland. The parietal layer is reflected to join the visceral along each side of the back border of the gland, leaving a narrow strip along the back uncovered. Here the place of the serous layer is taken by a thick lamella of unstriped muscle, the **internal muscular coat**. Along the border of reflection are numerous villi, clad with cylinder epithelium.

The wall of the tunica vaginalis is not very vascular, but in some cases becomes the seat of an abnormal secretion, owing to which the cavity becomes dropsical, the swelling constituting the disease *hydrocele*.

245. THE TESTIS is an oval, smooth, laterally compressed body, convex, and free in front, attached behind; obliquely suspended, so that its attached border is turned upwards and inwards, and its upper end projects a little forward. Each testis when well developed, in an adult man, measures 40 mm. in length, 29 mm. in breadth, and 23 in thickness; its volume is about 20 cm., and its weight 23 grammes, but the gland is variable in size, and atrophies with old age.

Along its hinder side is appended a curved structure, the **epididymis**, whose

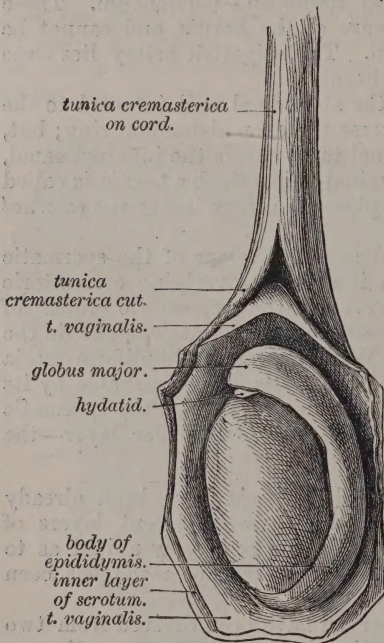


Fig. 498.—Left testis with the tunica vaginalis opened.

larger end or *globus major* (fig. 498) is above, its *body* passes along the back of the testis, from which it is separated externally by the *digital fossa*, and its lower end or *globus minor* is below. To the front of the testis, anterior to the globus major of the epididymis, there is appended a minute stalked body, the **pedunculated hydatid**, and a small sessile body of similar nature is placed beside it, the **sessile hydatid**.

These are covered by ciliated epithelium, and consist of minute rudimentary tubules communicating by one end with the tunica vaginalis and with the other end blind.

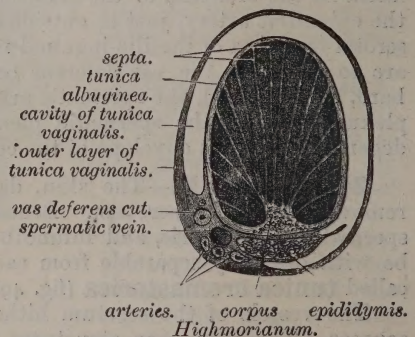


Fig. 499.—Horizontal section through the testis.

Above the testis, on the front of the vas deferens in the spermatic cord, there can be seen, easily in the child, not so easily in the adult, two or three small masses of convoluted tubes, about 7 mm. in diameter—the **paradidymis**—each of which is lined by an imperfect ciliated epithelium (p. 17).

The body of the testis is enclosed in a fibrous capsule (the **tunica albuginea**), which is composed of interlacing layers of white tissue, which interlace each other in all directions.

Fix the testis on a flat piece of wood by laying it on its outer side, and passing a pin through its upper and one through its lower end. Divide the tunica albuginea along the front of the gland, and reflect it on the inner side as far as the level at which the vessels enter.

Along the back of the gland the tunica albuginea is involuted as a thick reticulated fold, the **corpus Highmorianum**, which projects for about 8 mm.

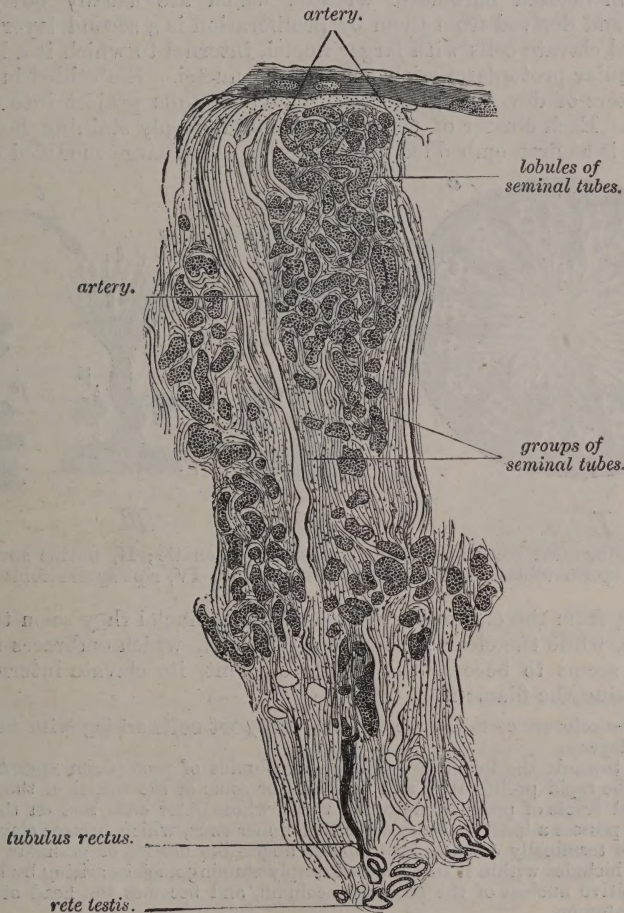


Fig. 500.—Magnified portion of testis.

into the substance of the gland and through which the vessels and nerves pass. From this there pass two kinds of processes through the gland tissue—(1) fine membranous septa which imperfectly divide the gland into somewhat conical lobules of irregular size; and (2) filaments of fibrous tissue containing unstriped

muscle. There are about 120 such lobules in each testis. Each lobule when teased out consists of from two to eight convoluted **tubuli seminiferi**.

These tubes are about 800 in number, each about .3 mm. in diameter, and beginning by loops, or diverticula, with closed ends, or by bifurcating and joining their neighbours. When fully teased out these tubules measure from 34 to 50 cm. in length, and are of fairly uniform diameter. Each tube consists of a homogeneous basement layer, outside which is a thick layer of flat connective cells arranged in interrupted laminae, one over the other, and appearing from the interruptions striated in cross-section, the outer cells passing gradually into the interstitial tissue. A close capillary network of vessels surrounds each tube. The epithelial lining of the tube is thick, and divided into layers, which are not always clearly separate, nor are the contiguous cells sharply bounded. Lining the basement is a layer of cubical **lining cells** with small nuclei, consisting of unenclosed chromatic wreaths which are usually fairly regular. Upon these and derived from them by proliferation is a second layer of irregularly rounded clavate cells with larger nuclei, internal to which is a layer of ill-defined granular protoplasm with small faint nuclei. Embedded in this layer are the clusters of developing spermatozoa whose tails project into the lumen of the tube. Each cluster of the elongated and deeply staining heads of the spermatozoa is at first embedded in a capsular cell, a large modified cell of the

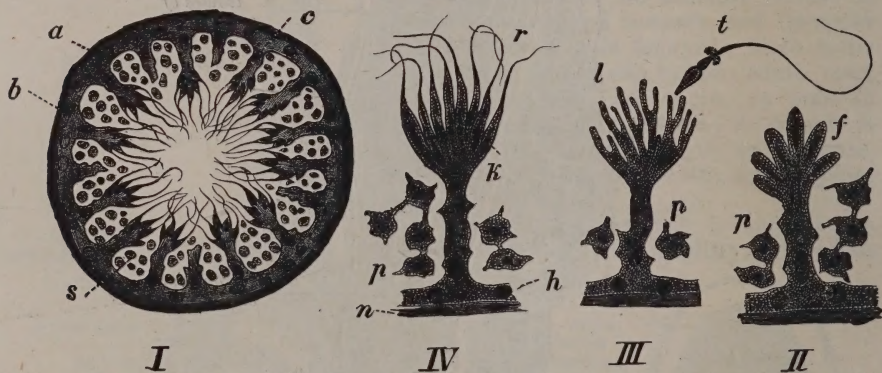


Fig. 501.—I, Magnified section of seminal tube, diagrammatic; II, unripe spermatozoon; III, spermatozoon, with detached spermatozoa; IV, ripe spermatozoon.

second layer, from the chromatic wreath of whose nuclei they seem to arise by karyokinesis, while the clear substance of the cell, which embraces the pole of the nucleus, seems to become the middle element, its clavate internal prolongation becoming the filament.

Among these cells are certain large columnar **support cells** arising with their bases on the basement layer.

Projecting towards the lumen are prominent columns of protoplasm **spermatoblasts** produced by the rapid proliferation and ingrowth of some of the nuclei of the lining cells, with undivided tracts of protoplasm around them, whose outer ends rest on the basement, and here each possess a basal nucleus, while their inner ends, which become clavate towards the lumen, are terminally divided into lobular finger-like masses of granular protoplasm, each of which includes within it an elongated deeply staining nucleus arising by karyokinesis from the primitive nucleus of the spermatogenic column, and becomes the head of the newly-forming spermatozoon.

Each of these lobules elongates, and the clearer material on the inner side of the nucleus grasps in growth the extremity of that body and forms the middle piece of the spermatozoon, while the portion of the clavate process lengthening towards the lumen becomes the tail. When these are fully developed, the cluster of contiguous spermatozoa lie with their tails twisted into a volute projecting into the lumen of the tube into which they subsequently are set free by the detachment of their heads.

Between these columns are other cells of varying forms, those resting on the lining cells being generally clavate, while next to the lumen of the tube in the intervals between the spermatozoon-forming lobes is a layer of ill-defined granular amoeboid masses of protoplasm, seminal cells, the breaking down of which produces the fluid wherein the spermatozoa float.

Each spermatozoon is $50\ \mu$ long, with a flattened pear-shaped head, a rod-shaped middle piece, and a filament or flagellum.

The interstitial tissue around these tubules is formed of fine fascicles of areolar tissue covered by flattened endothelium, thus founding a universal series of lymph clefts through the gland. The capillaries lie in the angular spaces between the tubules, and when injected, since they are numerous in the interstitial tissue towards the surface, they are described as forming a tunica vasculosa beneath the albuginea. There is, however, no such layer separate from the general interstitial tissue.

The tubuli seminiferi coalesce towards the apices of the lobules, and by their union they form shorter narrower **tubuli recti** (fig. 500), of which there are usually about 160 in a well-formed testis. These converge towards the corpus Highmori, which they enter. Each straight tube is about 3 mm. long and 0.3 mm. in diameter, and is lined by a single layer of cubical epithelium. When each straight tubule enters the corpus Highmori the basement layer becomes lost in the tissue of that structure and its cavity is continued as a tubular epithelium-lined excavation in the tissue, which divides irregularly, its branches reuniting in a labyrinthine manner, making the **rete testis** (fig. 502). When the tubules of the rete have reached the surface of the upper end of the corpus Highmori they again become distinct, and leave the gland as **vasa efferentia**. Of these there are about twenty, arising in a cluster at the top of the back part of the gland, and each vas, straight at first, becomes convoluted, and so forms a conical mass, whose base approaches the epididymis. To these conical masses of the efferent ducts the name **coni vasculosi** is given. Each conus is about 8 mm. long, but consists of about 15 cm. of tubing, diminishing in calibre towards the epididymis. In the wall of this tube is a layer of circular smooth muscle cells, and, like the epididymis, its lining epithelium is columnar beset with long cilia.

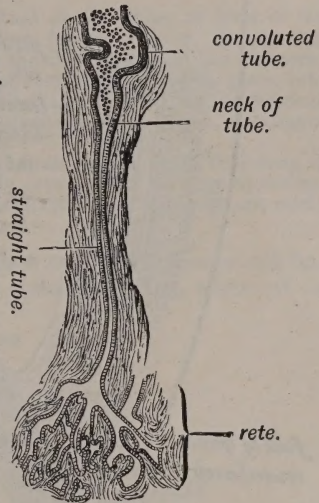


Fig. 502.—Convoluted tube of testis opening into straight tube.

The **epididymis**, which appears as a solid mass, can, by teasing, be resolved into a single tortuous tube nearly 6 metres long and 0.4 mm. in diameter. It begins small by the union of the uppermost two **coni vasculosi**, and receives the terminal ducts of the successive cones at distances of about 7 cm. The first two and a half metres of the tube are coiled and form the **globus major**, or upper end; the succeeding metre and half form the **body**, which is enclosed in a firm fibrous sheath that sends in lamellar processes to support the successive coils of the tube. Its coats thicken but its lumen diminishes as it descends, and near its lower end it often sends off short diverticula.

The wall of the tube of the epididymis consists of a strong areolar, a muscular coat, and a ciliated columnar epithelial lining.

The **globus minor** of the epididymis lies at the lower part of the testis, and at its lower end its tube is continued into the duct or **vas deferens**, which at first is wavy and ascends under cover of the internal muscular layer

on the inner side of the back of the testis, separated from the epididymis by the vessels, but soon becomes straight and ascends in the spermatic cord to the external abdominal ring, which it enters, and, traversing the inguinal canal behind the blood-vessels, it enters into the abdomen through the internal ring; here it parts company with the vessels of the testis and turns inwards, winding round on the outer side of the epigastric artery, to which it becomes posterior. From thence it descends under the peritoneum and across the external iliac artery and vein, crossing to the inner side of the vesical and obliterated hypogastric artery in the lateral false ligament of the bladder, along which it passes to the back of that viscus, where it crosses and gets internal to the ureter and descends, converging towards its fellow, internal to the vesicula seminalis, to open by a common duct with that sac into the prostatic part of the urethra.

The whole vas is about 60 cm. long and 2.5 mm. in diameter. It is thick-walled and cord-like, and consists of a fibrous areolar coat, a muscular coat of external longitudinal and inner circular fibres, and a mucous coat, arranged

in longitudinal folds, consisting of a firm submucous lamella and a thin corium, lined by columnar nonciliated epithelium. Where the tube is sacculated and tortuous, as at either end, the mucous membrane is obliquely ridged and the wall is beset with scattered simple tubular glands; while it is in the spermatic cord there is an interrupted inner layer of longitudinal muscular fibres within the circular.

Close to the region of the vas deferens there is a short cæcal tube, the *vas aberrans*, which when unfolded is about 3 cm. long, and which is rolled up close to the outer side of the globus minor. The vas deferens receives its blood supply within the pelvis from the deferential branch of the vesical artery. There is a loose-meshed plexus of non-medullated nerves in its areolar coat, derived from the plexus around the vesical artery. The left vas is usually about 2 cm. longer than the right, and the coiled part at each end is when expanded one-third the length of the uncoiled part.

246. THE SPERMATIC

ARTERY from the abdominal aorta (§ 276) divides at the top of the back of the testis into fine branches which traverse the corpus Highmorianum to break up in the interstitial tissue. The veins are larger than the arteries and escape from the corpus Highmorianum by several trunks, and as these when injected appear to surround the artery like so many tendrils, they have been named the **plexus pampiniforme**. Those on the left are liable to become varicose and dilate

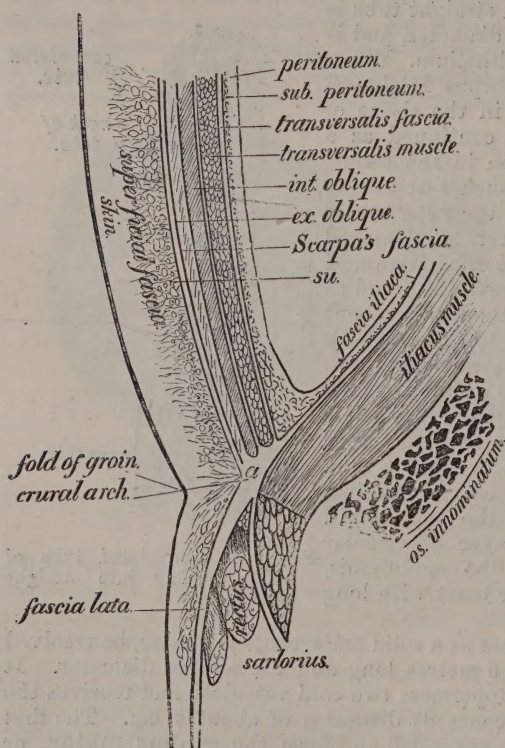


Fig. 503.—Vertical section through the crural arch and abdominal wall opposite the middle of Poupart's ligament.

into a tumor which feels like a bag of worms, constituting the disease varicocele. The pressure of the sigmoid flexure of the colon, under which these veins pass, is a powerful factor in producing this condition.

The lymphatics of the testis are very numerous, arising in the lymph clefts among the tubes and becoming tubular with definite walls as they traverse the corpus Highmorianum. They ascend with the veins in the cord and first reach a lymphatic gland in the iliac fossa.

The nerves form a close plexus on the spermatic artery. They have been traced into the interstitial tissue, but their mode of ending is unknown.

247. SUB-PERITONEAL TISSUES.—Divide the transversalis fascia about 3 cm. above Poupart's ligament, and separate it from the underlying sub-peritoneal areolar tissue. Along the iliac crest and Poupart's ligament external to the femoral vessels its lower margin is attached to the fascia covering the iliac muscle (*f. iliaca*—fig. 503), the line of junction appearing as a *white line of amalgamation*, closely connected to Poupart's ligament. In front of the femoral vessels the fascia transversalis is prolonged for a short distance downwards into the thigh behind Poupart's ligament, merging below in the sheath of the vessels. Internal to the vessels it is attached to the pubis behind the conjoined tendons, and descends into the pelvis.

The tissue between the transversalis fascia and the back of the pubes in front of the bladder is lax, and can be easily broken down by the finger, leaving a space, the **cavum præperitoneale**. In the fœtus the bladder is placed on the anterior wall of the abdomen, and it is not until the pelvic cavity develops that the organ sinks from its earlier place, into which, when over-distended, it can partially rise again. We have, however, in the deficient hinder wall of the rectal sheath, a trace of the original situation of the viscus, the upper border of which is marked by the semilunar line of Douglas.

The anatomy of the abdominal wall is surgically important on account of the frequency of the occurrence of hernia. A hernia is the protrusion of an organ out of its natural cavity, and the commonest sorts of abdominal herniæ are three—inguinal, along the spermatic cord; femoral, on the inside of the femoral vein; and umbilical.

The sub-peritoneal areolar layer consists of loose connective tissue and fat. It is thicker and tougher opposite the internal abdominal ring, where it is called the *fascia propria* of Cooper. By careful dissection at this place, the delicate cord-like trace of the original peritoneal prolongation along the spermatic cord may be seen.

248. INGUINAL

POUCHES.—On removing the sub-peritoneal fatty tissue, three obliterated tubes can be seen, as solid white cords, ascending on the front wall of the abdomen, and converging towards the umbilicus; the central of these is the *urachus*, continuous from the fundus of the

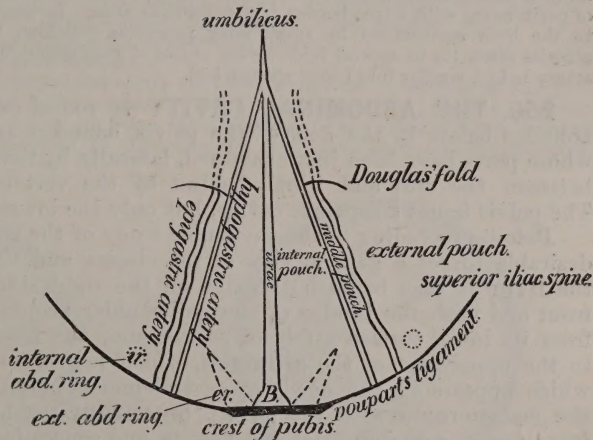


Fig. 504.—Diagram of abdominal wall, showing the position of the inguinal pouches and abdominal rings.

bladder to the umbilicus; and on each side is the *hypogastric artery*. Between these, on each side, is a triangular space with its apex above and its base below at the pubes and Poupart's ligament, wherein the peritoneum bulges slightly forwards, the **internal inguinal pouch** of peritoneum, which lies directly behind the superficial abdominal ring. A hernia which protrudes in this

space is a *direct inguinal hernia*. External to the hypogastric artery, and nearly parallel to it, lies the *epigastric artery*.

Occasionally a **middle inguinal pouch** bulges between the epigastric and hypogastric vessels, and sometimes, though rarely, a hernia leaves the abdominal cavity in this place to burst through the conjoined tendon, and thus to enter the inguinal canal. Such a hernia has the epigastric artery to its outer, and the hypogastric cord to its inner side; and is called a *superior direct hernia*.

External to the line of the epigastric artery, the peritoneum bulges a little forwards in a triangle whose base is at Poupart's ligament, whose inner side is the epigastric artery, and whose outer side is an imaginary line drawn from the superior iliac spine to the umbilicus. This **external inguinal pouch** corresponds to the deep abdominal ring (fig. 504, *iv*), and a hernia protruding in this region is an oblique inguinal hernia (the commonest form) having the epigastric artery on its inner side.

(The student should here replace the layers of the abdominal wall and review the parts bounding the inguinal canal.)

249. PERITONEAL ELEMENT OF THE ANTERIOR ABDOMINAL WALL.—

Dissect off the remainder of the sub-peritoneal tissue so as to expose the outer surface of the peritoneum, which is the largest serous sac in the body, and consists of a layer of endothelium on a thin, but very elastic connective tissue basis. Its cavity is to be opened by making five radial incisions from the umbilicus—one to the metasternum, one to the cartilage of the twelfth rib on each side, one to the superior iliac spine on one side, and one to the middle of Poupart's ligament on the opposite side. By reflecting these flaps of parietal peritoneum the cavity is laid open. The appearance of the inguinal pouches, and the faint **superior digital fossa** which corresponds to the deep abdominal ring, should be noticed as they appear on the inside.

Note also the appearance of the **inferior digital fossa** below Poupart's ligament and internal to the femoral vein, corresponding to the upper opening of the femoral canal.

In the right upper flap the obliterated umbilical vein can be traced through a special canal of fascia transversalis (*Richet's fascia*) open above, and passing from thence into a fold of peritoneum with a free border directed downwards. In this *falciform ligament*, it ascends to the liver surrounded by small fatty processes. Below, the urachus and hypogastric arteries often lie in special folds (*plicæ urachæ et umbilicales*), and occasionally the epigastric artery is in a similar fold (*plica epigastrica*).

250. THE ABDOMINAL CAVITY is roofed above by the diaphragm, bounded below by the floor of the pelvis, bounded anteriorly by the soft wall, whose parts have been just examined, laterally by the iliac alæ and the muscles between the ribs and ilium, behind by the vertebræ and lumbar muscles. The pelvis is not a separate cavity, but only the lowest part of the abdomen.

Before proceeding to the particular study of the contents of the cavity, it is desirable to get a general view of the viscera and their connections. Above, the **liver** is seen beneath the ribs on the right side, with its thin border in front and with the fundus of the gall-bladder projecting at its anterior edge; from its lower surface a fold of peritoneum, the **lesser omentum**, descends to the upper edge of the **stomach**, which lies below and to its left side, and which appears in the newly opened abdomen bulging to the left side below the metasternum with the **great omentum** pendent therefrom like a wide loose apron, containing fat and vessels, and concealing all the underlying parts except certain convolutions of small intestine to the left and below. On tracing the lesser omentum to the right between the gall-bladder and the right end of the stomach, it will be found to end in a free border, behind which the finger slips into an opening directed to the left, the **foramen of Winslow**, having the liver above it, and the first part of the intestine (duodenum) arising from the stomach below it. The cavity whereinto this opening leads, is the **bag of the omentum**. Leftward, above and behind the stomach, is the **spleen**, below which is a shelf-like fold of peritoneum, the **pleurocolic fold**.

When the great omentum is raised up towards the ribs a large sacculated intestine, the **transverse colon**, is seen to cross in its deep surface from right to left, forming below the spleen a sharp *splenic flexure* as it turns downwards into the left lumbar region in front of the kidney (whose edge bulges to its inner side). Entering the left inguinal region, the gut is coiled several times in a sinuous fold, the *sigmoid flexure*, and is finally traceable into the pelvis in front of the sacrum to end in the **rectum**.

If the transverse colon be traced rightwards from the middle line, it is seen to ascend under the liver, where it turns sharply downwards, forming the *hepatic flexure*. From this point it can be traced downwards in the right lumbar region to the right iliac fossa, where it slightly dilates, forming the **cæcum**. From this two tubes are traceable, one minute, short, and blind (the **vermiform appendix**), about the size of a quill and 10 cm. long, the other, the small intestine, a convoluted tube, 6·8 metres long, attached to the spine by a plaited fold, the **mesentery**, as far as the left side of the epigastric region, where it again forms a sharp turn and becomes continuous with the duodenum, sinking out of view by burrowing through the attached part of the mesentery and descending to a point on the right side leftward of the cæcum from whence it ascends, still deeply placed behind the hepatic flexure of the colon to join the stomach below the foramen of Winslow. Of this small intestine the two-thirds nearest the cæcum is called **ileum**, the upper third joining this to the duodenum is the **jejunum**.

251. PERITONEUM.—The serous lining of the abdomen is derived from the lining of the cœlom (p. 8), and is reflected around the different viscera as a continuous layer. On account of the complexity of arrangement of the viscera this continuity is not easily traced, but it becomes intelligible when the growth of the organs is understood.

In the primitive embryonic abdominal cavity the hypoblastic tube or *mesodæum* (fig. 505) is slung to the vertebral column by a continuous vertical mesogastric fold, which extends to the ventral wall of the cavity above and below the umbilicus. The cœlom of the abdominal region is thus divided above and below the umbilicus into two lateral parts, and the primitive

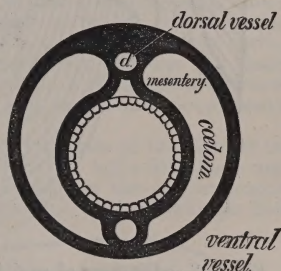


Fig. 505.—Primitive arrangement of peritoneum on mesodæum. The thick black line is peritoneum.

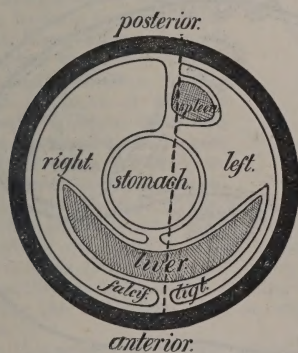


Fig. 506.—Diagram of section of embryonic abdomen above the umbilicus.

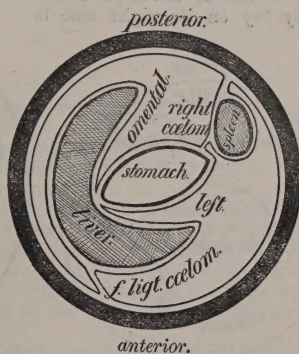


Fig. 507.—Diagram showing change of position of stomach whereby its right side becomes omental and its left becomes anterior.

serous fold consists of three parts, the continuous *dorsal mesentery* between the mesodæum and the spine, a *superior ventral mesentery* between the mesodæum and the ventral wall above the umbilicus, and an *inferior ventral mesentery* below the umbilicus. In the free

edge of the former ventral mesentery (fig. 506, *falcif. lig.*) is the surviving left umbilical vein; in the free edge of the latter is the urachus or pedicle of the allantois.

The liver develops in the upper ventral mesentery, and its connections with the great veins close to the heart, cause it to rise above and to the right of the differentiating stomach, and thereby to fix the duodenum from which it has been an outgrowth (p. 15). On this account the stomach, as it enlarges, is made to rotate around its vertical axis, its vertebral or convex border being turned forwards, while its ventral concave edge is turned backwards (fig. 507). Owing to this rotation, its mesogastric serous attachment

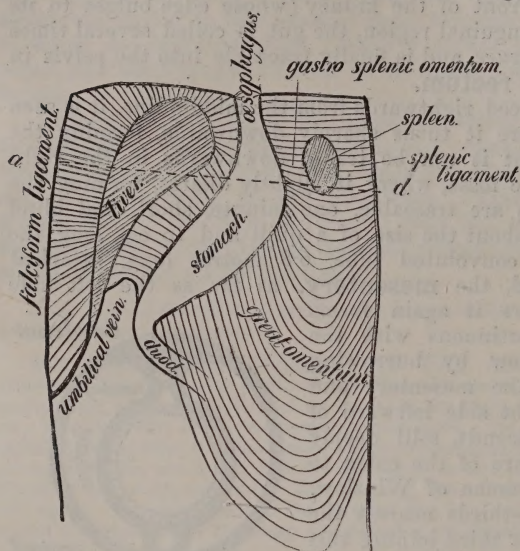


Fig. 508.—Diagram of sagittal section of primitive stomach and great omentum—*a, d*, is the line of section shown in fig. 506.

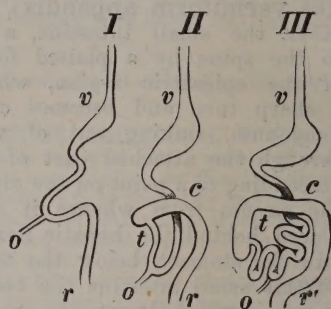


Fig. 509.—Diagram illustrating the mode of looping of the intestinal canal.

is pulled out from the spine as a long and doubled fold, the great omentum, while its ventral mesentery has become subdivided by the development of the liver into gastro-hepatic and hepato-parietal parts. As a result of this rotation, the original left side of the stomach becomes its foremost and the right side its hindmost surface.

The connection of the duodenum to the liver holds up that portion of the mesodæum, and in consequence the stomach as it elongates is bent around its sagittal axis. The serous envelope which originally lay on its right side is

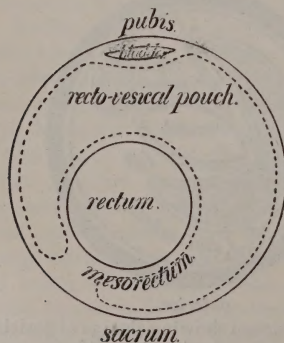


Fig. 510.—The dotted line represents the peritoneum as seen in section along the brim of the pelvis.

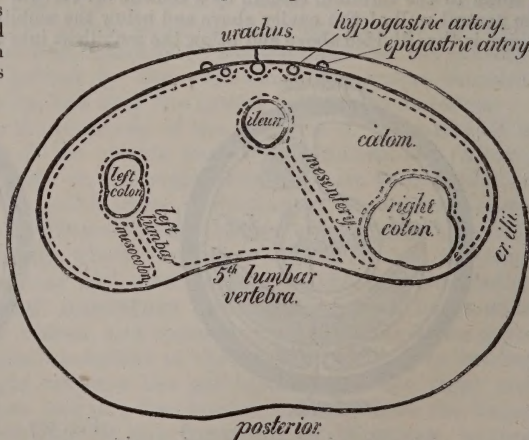


Fig. 511.—Section of abdomen on the level of the crest of the ilium. Diagram of the course of the peritoneum.

now turned behind it, and appears as the lining of a sac, whose orifice is constricted by the uprising of the duodenum, and which appears in the adult as the foramen of Winslow.

The lengthening of the coil of small intestine produces a modification in its peritoneal investment. The tube, elongating between two fixed points (*v* and *r*, fig. 509), becomes twisted on itself at one spot a little below the stomach, and at that point the lower portion of the twist passes in front of the upper and lifts the peritoneum from its ventral surface. The loop thus formed elongates rapidly but unequally, both above and below the umbilical pedicle, and as a consequence the vessels which supply the part of the intestine which is superficial pass over the hinder limb of the loop at the point of crossing.

These two peculiarities, the rotation of the stomach and the looped crossing of the intestine, constitute the only difficulties in the clear understanding of the course of the peritoneum.

The easiest method of tracing the course of the peritoneum in the adult is to follow along several lines of ideal section. The simplest line is that along the brim of the pelvis (fig. 510). Here the parietal layer passes along the ilio-pectineal line forwards towards the pubes, crossing the top of the bladder or urachus as it goes from side to side, leaving the abdominal wall at the left sacro-iliac synchondrosis to pass forwards and surround the sigmoid colon seen here in section, then returning to the spine it is continued around the front of the sacrum to the point of starting.

If in like manner we trace it in a transverse section of the abdomen at the level of the iliac crest (fig. 511), the membrane can be followed from the medio-ventral line rightwards as it lines the abdominal wall as far as the commencement of the ascending colon, here it passes in front of the intestine, returning to the abdominal wall on its left side to project again as the right lamina of the lower part of the mesentery to surround the lower portion of the ileum. Returning thence as the left lamina of the mesentery, it crosses the hinder wall of the abdomen to the left to be again reflected forwards in a third fold to surround the left colon, leftward of which it returns to the abdominal wall, on which it is continuous forwards to the point of starting.

If we now rise to a higher level, and trace the membrane as it appears on the plane of the twelfth dorsal vertebra (fig. 512), the arrangement is of a similar kind, but a little more complicated. Starting the tracing in the ventral median line the edge of the cut peritoneum can be followed to the left, lining the abdominal wall and the edge of the diaphragm back nearly as far as the spine, whence it is reflected forwards on the back and left side of the spleen. It covers this viscus to its anterior margin and nearly the front half of its right surface, and is from thence reflected rightwards to the left end of the stomach, and is continued over the anterior surface of that organ to its concave margin, and can be traced rightwards beyond that margin for a short distance, forming the front layer of the lesser omentum until it reaches the great vessels ascending to the liver. Having passed in front of these it suddenly turns on itself and passes leftwards behind these vessels, forming a hinder layer for the lesser omentum, reaching the concave edge of the stomach on this returning course, it passes behind that organ, investing its posterior surface to its convex edge, and from thence is continued leftwards to the spleen, on reaching which organ it passes back to the hinder wall of the abdomen. Here it again turns rightward, fixing the pancreas against the vertebral wall of the abdomen, and continuous to the right, forming the hinder limit of the foramen of Winslow, and finally reaching the abdominal wall on which it continues to the point at which the tracing was begun.

In this section it is to be noticed that the part of the peritoneum which lies behind the stomach appears to form a separate second pouch, but is really that which originally lay on the right side of the stomach when it was a median organ. By passing the finger through the foramen of Winslow, it will be found that the sac of the omentum expands upwards behind the liver, and downwards behind the stomach into the folds of the great omentum, but as the opening of communication between this sac and the rest of the peritoneum has become so restricted by the growth of the parts around it, so in any other section involving

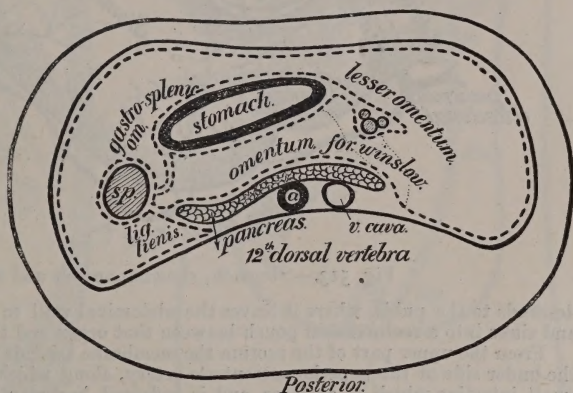


Fig. 512.—Arrangement of peritoneum in transverse section opposite the twelfth dorsal vertebra.

the omental cavity, the connection between the omental pouch and the general abdominal cavity is not apparent, and the lines of cut membrane appear independent.

The omental pouch is hourglass-shaped, being medially constricted on the plane of the upper edge of the stomach. This can be shown by opening the lesser omentum above the concave edge of the stomach (taking care not to cut any of the contained vessels), and drawing the stomach a little downwards and forwards, the cavity now opened (the lesser omental sac) communicates with the lower and larger great omental sac by a **mesenteric opening** of variable size, whose margins leftwards and rightwards project as two usually crescentic folds, the left and right *pancreatico-gastric* folds. In the left *pancreatico-gastric* fold is contained the gastric artery, in the right are the hepatic artery, vena portæ, and hepatic duct, the former is generally the sharper and more prominent.

We are now in a position to understand the appearances seen in a median sagittal section through the abdominal cavity. Starting in such a section at the umbilicus, the peritoneum

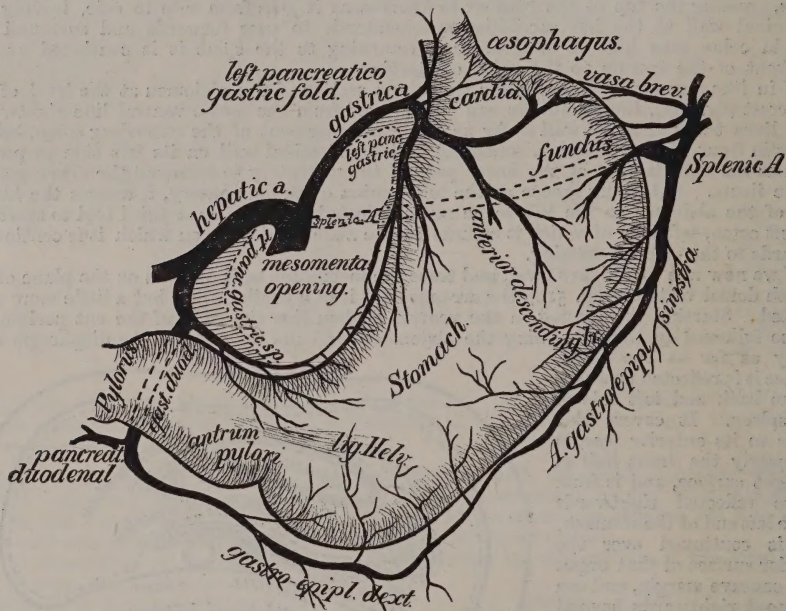


Fig. 513.—Stomach, showing vessels and serous folds.

descends to the pubis, where it leaves the abdominal wall to cover the back of the bladder and sinks into a recto-vesical pouch between that organ and the front of the rectum.

From the upper part of the rectum the membrane ascends on the abdominal wall as far as the under side of the superior mesenteric artery, along which it is continued forwards to the small intestine which it encloses, and is reflected backwards on the upper surface of the superior mesenteric artery to the spine, which it reaches close to the lower part of the duodenum, which it fixes against the abdominal wall. From this point it is reflected again as the under layer of the transverse meso-colon as far as the transverse colon, having here the under side of the omental bag in contact with its upper surface; hence, at this point, it appears bilaminar, the omental layer separating from it when it reaches the colon, and passing above it, while the primitive layer which we are tracing passes below it. In front of the colon, however, these two layers again come in contact, and descend together, forming the posterior lamina of the great omentum, and these having reached the free edge of that fold, turn up together as the anterior lamina of the great omentum, until they meet the convex edge of the stomach. Here again these two layers separate, the anterior layer passing in front of the stomach, while the omental layer lies behind it; they again come in contact at the concave edge of the stomach, and ascend together, forming the lesser omentum to the under surface of the liver. Here they finally part company, the primitive lamina passing forwards, clothing the front of the under surface of the liver, its thin edge and its upper surface, nearly to its hinder margin, whereat it is reflected on the diaphragm, and is thence continuous forwards on the abdominal wall to the point at which our tracing began. The omental layer, on the other hand, covers the Spiegelian lobe of the liver, is thence reflected

on the back wall of the abdomen on which it descends to the point where we first met it at the transverse meso-colon. In this section for the obvious reasons already mentioned, the relations of continuity between the omental and the general layers of peritoneum are not apparent, but will be seen by comparing this diagram with that of the transverse section through the foramen of Winslow.

If the organs of the abdomen be removed by cutting across the various peritoneal folds at the points where they leave the abdominal wall, the appearance of the cut edge of the membrane seen would be that shown in the diagram. In this dissection the hinder limb of the loop of intestine (duodenum), which is pressed back against the abdominal wall, is seen cut above and below, and the continuity of what was the original line of attachment of the mesogastric fold is on that account complicated by the parietal reflection of the peritoneum within the long intestinal loop to the right side; the various lateral projections from the area of attachment of the mesogastric fold are mostly determined by the presence of blood-vessels.

The folds of peritoneum which pass from the abdominal wall to the intestines are named from the viscera to which they are severally attached. Folds passing from one viscus to the other are limited to those forming parts of the wall of the secondary pouch, and are called **omenta** from their historical connection with extispicious augury. Folds from the

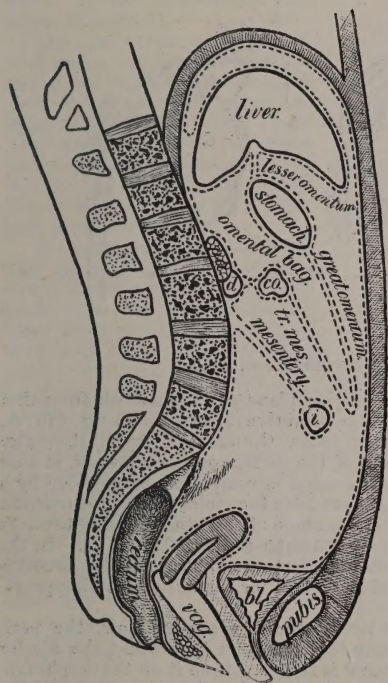


Fig. 514.—Diagram of peritoneum in vertical sagittal section in the female.

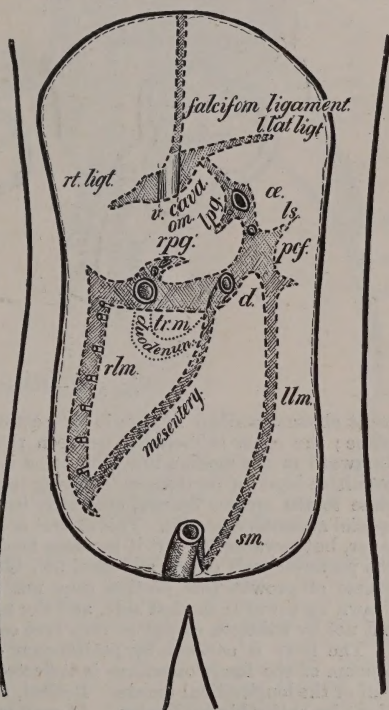


Fig. 515.—Diagram of hinder wall of the eviscerated abdomen, showing the lines of peritoneal reflection.

abdominal wall to solid organs are called **ligaments**. Abdominal organs differ in the amount of their peritoneal investment; some, like the small intestines and sigmoid colon, being covered except at one border, the on- and off-going layers being closely approximated at the line of reflection, only allowing a narrow intermediate line for the passage of vessels. The spleen is nearly as well covered, but its peritoneal reflections are double—one, the bilaminar **gastro-splenic omentum** in front containing the vasa brevia and left gastro-epiploic artery, the second or **ligamentum lienale** containing the splenic artery and vein between its layers. It should be noted that the hinder layer of the gastro-splenic omentum and the right layer of the ligamentum lienale are formed of the left wall of the omental sac, and as this does not extend up as far as the top of the spleen, there is a short space at the upper

part of the organ, at which the front layer of the gastro-splenic omentum comes in contact with the back layer of the ligament, making the **phreno-splenic ligament**.

The cæcum is usually completely covered with peritoneum.

Other organs, such as the ascending colon, some parts of the descending colon, and the upper part of the rectum, are covered except at one wide strip or border, the off- and on-going layers of peritoneum not being contiguous.

In a third group the peritoneum is reflected on at one border and off at another. This is seen in the transverse colon and stomach. The former receives its two layers as the lesser omentum above and gives them off as the greater omentum below, the uncovered areas being only the margins, and the small space between the layers of the left pancreatico-gastric fold.

The omenta are peculiar in structure, being more vascular than the rest of the peritoneum, and always fenestrated, the holes being oval, separated either by narrow single bands of fibres or by broader bands, containing vessels, lymph spaces, and fat. The edges of these holes are covered by endothelium; single endothelial cells often enwrap the smaller bands. The greater omentum has usually much fat in its substance.

The relations of the transverse colon to the posterior layers of the great omentum differ according to the sagittal plane in which it is examined. At all periods of life the arrange-

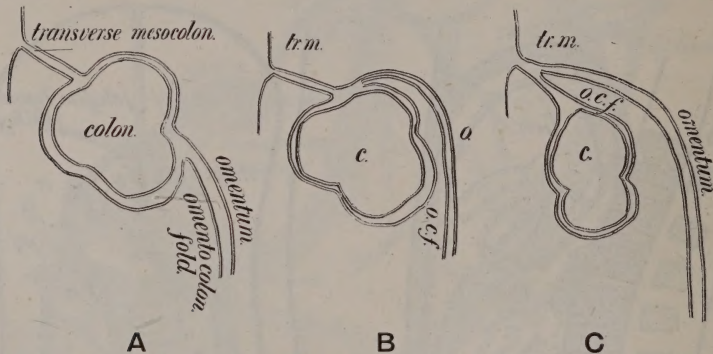


Fig. 516.—Relation of colon to omentum.

ment above described is seen in all sections in the median plane and rightwards from that plane; the colon is included between the omental and primitive layers, as in fig. 516, **A**. Leftward of the median line, the colon is seen to drop below the omental layer, the outer primitive layer of peritoneum covering more and more of the surface of the intestine, so that close to the splenic flexure, especially in the fœtus, the colon is completely surrounded by a special mesentery (*ib.*, **B**). This at first is simply a pendant from the under side of the omental layer, but towards the left it becomes finally separate, the angle of reflection dipping towards the posterior wall of the abdomen (*ib.*, **C**), forming an **omento-colic fold** (*o.c.f.*). In the course of growth this portion does not usually continue separate, but gradually becomes drawn up towards the left side, and the separate mesocolic fold for the most part disappears, but not by adhesion except in very rare cases.

The liver is covered by peritoneum except at two irregular areas. Below, the peritoneum of the lesser omentum is reflected on it along the transverse fissure and the hinder half of the longitudinal fissure. Behind, the peritoneum is reflected from it on the diaphragm along its entire hinder border. At each end of this margin, there is only a linear area of the gland uncovered, as the layers reflected from the upper and lower surfaces of the liver on the diaphragm are in contact, and these parts are called the **right and left lateral ligaments** of the liver. In the middle, however, there is a wide space of the hinder surface of the liver between the upper and lower layers of peritoneum, and this portion of the reflection is called the **coronary ligament**. The surviving portion of the upper ventral mesentery which crosses the upper surface of the liver is the **falciform ligament**, which carries the obliterated umbilical vein in its free border. In this fold are the traces of the original prehepatic abdominal veins as well as lymphatic and other vessels.

The pancreas and kidneys are only covered by peritoneum on their ventral surface. The left suprarenal capsule is often totally uncovered, the peritoneum being lifted from it, as it is sometimes from a portion of the middle stage of the duodenum.

The middle third of the rectum is only covered with peritoneum on its anterior wall. The bladder is covered for the whole of its posterior, superior, and the hinder half of each lateral surface. The distance to which the **recto-vesical pouch** descends is somewhat

variable, and the student should, by passing one finger into the rectum and the other in the pouch, familiarise himself with the peritoneal relations of these viscera in as many subjects as possible.

False ligaments of bladder.—The border of reflection of the peritoneum from the bladder is a continuous one, but in the medio-ventral line where the urachus projects, there is a special fold of the membrane around that cord which is called the **superior false ligament** of the bladder.

When this organ is partially distended, the peritoneum on its hinder surface at each side of the recto-vesical pouch forms a prominent falciform fold, the **posterior false ligament**, in whose pelvic attachment the ureter is enclosed.

The continuous reflection of peritoneum between the superior and posterior false ligaments on each side is sometimes called the **lateral false ligament**. These have no distinct limits, and under this portion of peritoneum on each side lie the vas deferens, vesical artery, and the obliterated hypogastric artery.

In the female there is a **recto-uterine pouch** (fig. 514) in place of the recto-vesical, in which the peritoneum dips downward to cover the entire posterior uterine surface, and the upper fifth of the hinder wall of the vagina. On each side, it is reflected from the uterus in the form of the broad ligament which contains the Fallopian tube, round ligament, and the ovary. From the anterior surface of the uterus, which, except the anterior lip of the cervix, is covered with peritoneum, it is reflected on the back of the bladder and thence on the abdominal wall.

252. ABDOMINAL VISCERA.—The organs contained in the abdominal cavity are the digestive, urogenital, and blood-glands. The digestive organs are twofold, the alimentary tube and the glands appended thereto. These parts are now to be studied in order.

The oral end of the alimentary canal (mouth and pharynx) is described in connection with the parts in the neck (§ 450, *et seq.*) It is, however, of advantage, for the sake of continuity, to commence our description of the hollow digestive organs with the oesophagus, although that

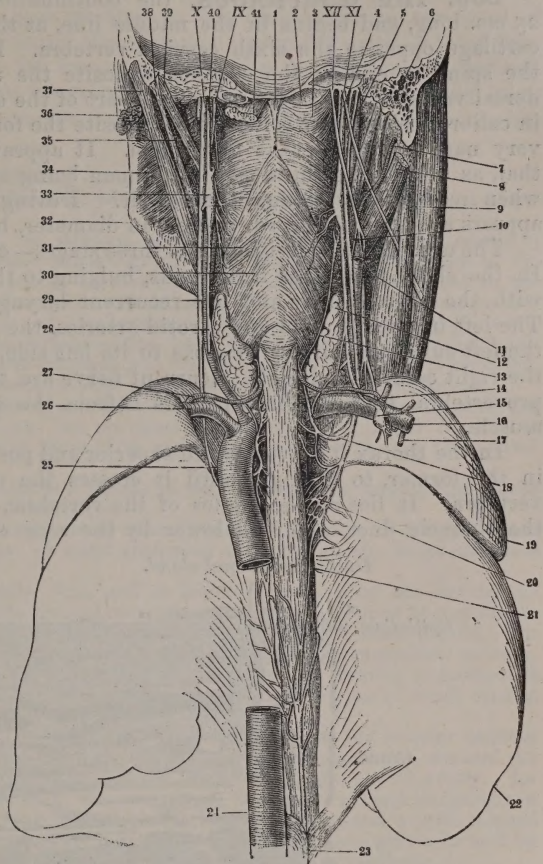


Fig. 517.—Back view of pharynx and oesophagus—1, pharyngeal spine; 2, sinus of Morgagni; 3, superior constrictor; 4, sympathetic; 5, internal carotid; 6, mastoid cells; 7, occipital artery; 8, digastric muscle; 9, sternomastoid; 10, vagus nerve; 11, jugular vein; 12, thyroid body; 13, recurrent laryngeal nerve; 14, inferior thyroid artery; 15, inferior cervical sympathetic ganglion; 16, subclavian artery; 17, internal mammary artery; 18, loop of recurrent laryngeal; 19, superior lobe of right lung; 20, posterior pulmonary plexus; 21, trunk of right vagus; 22, inferior lobe of right lung; 23, diaphragm; 24, dorsal aorta; 25, left vagus; 26, left subclavian; 27, left inferior thyroid; 28, sympathetic; 29, left carotid; 30, inferior constrictor of pharynx; 31, middle constrictor; 32, angle of jaw; 33, superior cervical sympathetic ganglion; 34, internal pterygoid; 35, stylohyoid; 36, sternomastoid; 37, digastric; 38, styloid process; 39, stylopharyngeus; 40, sympathetic; 41, rectus capitis anticus major.

organ cannot be dissected until the posterior mediastinum is opened, and the dissector of the abdomen may not be able to examine it until a later stage.

253. THE ŒSOPHAGUS, the continuation of the pharynx, is about 25 cm. long, and begins in the middle line, at the lower border of the cricoid cartilage opposite the sixth cervical vertebra. It descends thence in front of the spine to end in the stomach opposite the upper border of the eleventh dorsal vertebra. It is the narrowest part of the digestive canal, and is variable in calibre, being most constricted opposite the fourth dorsal vertebra, and also very narrow opposite the diaphragm. It appears in section as a cord rather than as a tube, its linear stellate lumen being scarcely visible, and only open when material is passing through it. During life, and in *rigor mortis*, it appears as a roundish cord, 11 mm. in diameter, but it flattens when relaxed.

The œsophagus is divisible into three stages—cervical, dorsal, and abdominal. In the short first stage it descends, bulging to the left of the trachea, which, with the thyroid body and left recurrent laryngeal nerve, lies in front of it. The left inferior thyroid and carotid arteries, the thoracic duct, and still lower, the left subclavian artery lie close to its left side, and on a plane anterior to it, the right carotid and right recurrent nerve are to its right, and it lies on the prevertebral fascia which separates it from the spine and the left *longus colli* muscle.

In the thorax it traverses the superior and posterior mediastina, descending, in the former, to the right until it crosses the median line at the fifth dorsal vertebra. It lies on the bodies of the vertebræ, from which it is separated by the thoracic duct, and still lower by the vena azygos and upper right inter-

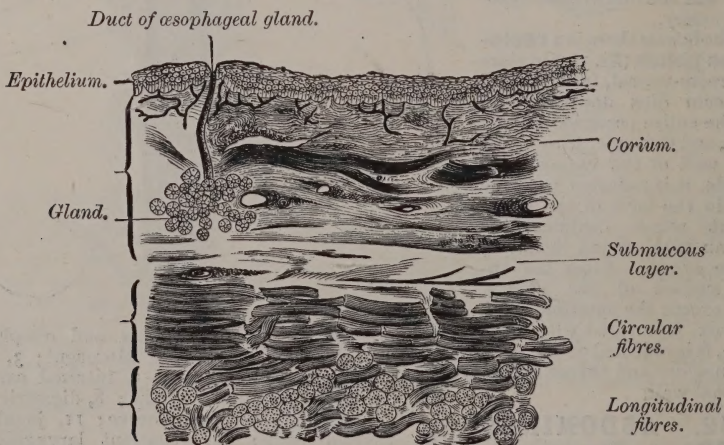


Fig. 518.—Transverse section of œsophagus magnified.

costal arteries. The left carotid, the trachea and its bifurcation, the left bronchus, right pulmonary artery, and bronchial glands lie in front of it. The left subclavian artery, the vagus and left pleura, the aortic arch, and the beginning of the descending aorta lie to its left. To its right are the trachea, bronchial glands, and some areolar tissue separating it from the right pleura.

In the posterior mediastinum the œsophagus descends forwards and to the left, lying at first on the spine, many communicating branches between the two vagi, vena azygos and right intercostal vessels, and, for the lower half of this space, on the aorta, which it crosses very obliquely. The right mediastino-costal sinus of pleura is closely related to it dipping behind it. In front, the pericardium separates it from the left auricle, and to the left is the aorta

and the left pleura below (fig. 451). The two vagi (§ 486) descend and form a plexus upon the œsophagus from the roots of the lungs, the left being rather anterior and the right posterior, and they continue along it to the stomach. It passes through the œsophageal opening in the diaphragm on the level of the tenth dorsal vertebra, and enter the abdomen behind the left lateral ligament of the liver, covered on its front and left sides by peritoneum derived from the anterior layer of the lesser omentum, its narrow hinder side lying on the diaphragm. It ends 2 cm. to the left of the middle line, at the cardiac orifice of the stomach.

The œsophagus consists of the following coats:—

(1) A loose, elastic connective *adventitia*, joining it to the neighbouring parts and allowing of distension.

(2) *Longitudinal fibres*, a thick red stratum, consisting for the upper third mostly of striped fibres. These begin as three bands—an anterior, the strongest attached to the vertical ridge on the back of the cricoid cartilage, and two lateral, each attached to the elastic tissue in which the *palato-pharyngeus* muscle ends. These three bands become confluent as the tube enters the thorax and supplementary longitudinal smooth fibres become added, arising from the left pleura, left bronchus, back of the trachea and pericardium. For the middle third the striped fibres decrease, and very few are present in the lower third. The longitudinal striped muscular fascicles show here and there tendinous intersections.

(3) A thinner layer of *circular fibres*, some of which are striped in the upper fourth of the tube. The bands are usually oblique, but are most transverse at the upper fourth, the fascicles being closed loops. A few of these fibres appear as if continuous from the *inferior constrictor*.

Between the two layers of muscle is a plexus of nerves containing large ganglion cells and both medullated and non-medullated fibres.

(4) *Submucous layer* of loose elastic areolar tissue, containing masses of adenoid tissue and short irregular longitudinal rows of small compound racemose glands, larger and more numerous below than above.

(5) *Mucous membrane*, thick, pale, firm, and so loosely connected by the last to the overlying coats that it lies folded into vertical rugæ beneath them. It is lined by a stratified scaly epithelium, beneath which the corium shows an irregular row of small papillæ. On its submucous surface is a longitudinal layer of unstriped muscle, the *muscularis mucosæ*, which is thin, and interrupted in the upper half of the tube, but forming a continuous stratum at the lower half. Near the stomach, there is an irregular ring of small cardiac glands, embedded in the mucous membrane.

The œsophagus receives in its cervical stage two branches from the inferior thyroid artery, in its thoracic stage four branches from the front of the thoracic aorta, whereof the lower are the larger, and in the abdomen it receives branches from the gastric artery. Its veins join the inferior thyroids in the neck, the *vena azygos* in the thorax, and the gastric in the abdomen. Its vessels form a long-meshed plexus in the mucous, and a cross-meshed plexus in the muscular layer. Its nerves are derived from the œsophageal plexus formed by the vagi, together with branches from the first dorsal ganglion of the sympathetic.

The œsophagus can be distended by injection to 14 mm. diameter at its commencement and at the two narrow points, and to 20 mm. elsewhere.

254. THE STOMACH, the widest part of the alimentary canal, is during life a corrugated sac, whose shape is influenced by the pressure of the surrounding parts, and whose size depends upon its degree of distension. When the abdomen is opened and the organ is inflated, it appears as a curved pyriform bag with its widest end leftward.* It is described as having two margins or edges of peritoneal reflection (fig. 513), the lesser curvature directed upwards, backwards and to the right, and mostly concave, along which the lesser omentum (fig. 513) is attached, and the greater curvature directed downwards and forwards, mostly convex, and giving attachment to the greater omentum. The anterior surface is in contact with the diaphragm to the left, the abdominal wall medially, and the liver to the right. The posterior surface rests on the spleen, gastro-splenic omentum, left kidney and suprarenal capsule, pancreas, great vessels and transverse mesocolon. The **cardiac** or **œsophageal orifice**

* This should not be done until later. The organ should at first be examined when flaccid.

is wide, and would be pierced by a needle driven horizontally backwards through the left seventh costal cartilage, 3 cm. from its junction with the sternum, and striking the spine at the left side of the eleventh dorsal vertebra. This opening varies little in position (fig. 519, 2). The **pyloric or intestinal orifice** lies, when the stomach is empty, near the median line lower, and a little farther forward. It would be pierced by a needle passed through the abdominal wall, 5 cm. below the junction of the right seventh costal cartilage with the sternum, to the disc between the last dorsal and first lumbar vertebra. This opening is, however, displaced rightwards from 1 to 7 cm., according to the degree of gastric distension; and the levels of the orifices vary within definite limits with sex, age, and with times and habits of feeding (*ib.*, 6).

To the left of the œsophagus is the **great cul de sac** or bulging end of the stomach (fig. 519, 3), projecting upwards and backwards towards the spleen.

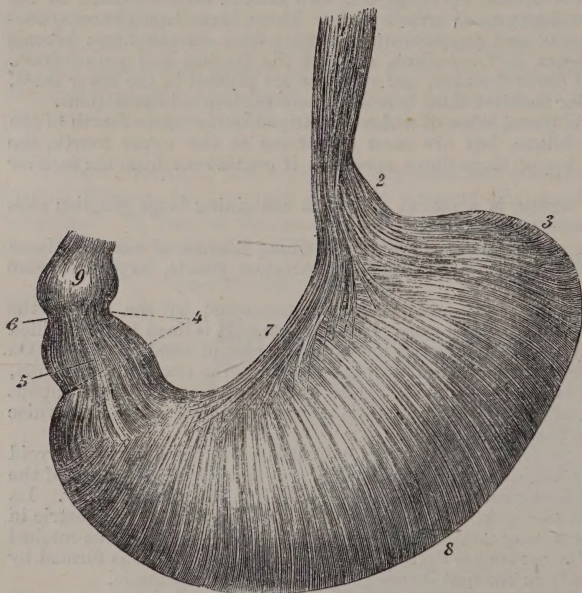


Fig. 519.—Longitudinal muscular fibres of stomach.

The lower border (*ib.*, 8) is uniformly convex as far as the pylorus, where there is a second bulge, the **lesser cul de sac** (*ib.*, 5). The pylorus feels like a thick ring, while the cardiac orifice feels thin. The lesser curvature is concave for its left three-fourths, but is convex at its right quarter, forming the **antrum pylori**. Occasionally there is a median constriction, dividing the stomach into two pouches.

Along the concave border the gastric artery anastomoses with the superior pyloric branch of the hepatic (fig. 513), and along the convex border the right and left gastro-epiploic arteries anastomose and are

joined by the vasa brevia branches of the splenic, which in turn communicate with the gastric artery, thus completing a ring of arteries around the stomach. These lie between the layers of peritoneum along each margin. The gastric veins are provided with imperfect valves, and usually accompany the arteries.

A normal male stomach weighs 130 grammes, and is, when distended, 28 cms. long and 10 cms. in diameter at its widest part, and capable of holding about 3.5 kilogrammes of water. Its walls are thicker than those of the intestine, and thinner than those of the œsophagus. The sectional area of its arteries is equal to that of the arteries of the liver.

At birth the cubic capacity of the infant's stomach is 36 c.cm., in one month it has increased to 180 c.cm., and at two years to 740 c.cm.

Inflate now the stomach through the œsophagus and ligature the duodenum 1 cm. beyond the pylorus. The coats can now be examined. These are:—

(1) *Serous*, closely adherent, except along the linear margins, the only wide area uncovered being a small triangular space about 2.5 cm. long at the back of the cardiac orifice bounded below by the top of the omental sac, and laterally by the peritoneum reflected around the œsophagus.

(2) *Longitudinal muscular layer* (fig. 519, 7), continuous with that of the œsophagus, strong along the concave edge, distinct, but weaker along the convex. Two lateral bands (**ligaments**

of Helvetius), mostly of connective tissue; but containing a few longitudinal fibres, produce the sacculation of the antrum pylori (fig. 513). The coating of longitudinal fibres becomes uniform at the pylorus.

(3) *Circular Fibres.*—These are arranged at the cardiac end in two sets—a superficial circular (fig. 520, 3) which annularly surround the stomach along its long axis from its left end to the pylorus and a deeper or oblique series (*ib.*, 4), the direct continuation of the circular fibres of the œsophagus which pass obliquely on the left side of the œsophageal opening and are directed downwards and to the right towards the great curvature, crossing beneath the superficial circular fibres which are here strong. Towards the right the two strata become confluent into a single thick layer of circular fibres which form by their sudden thickening the pyloric sphincter. The oblique fibres have generally a thick upper border towards the œsophagus, and it has been thought possible that by their action they might form a groove-like channel along the concave margin of the stomach. There is no special muscular sphincter at the cardiac end, the lower end of the œsophagus gradually expanding in a funnel-shaped manner to the stomach; but the muscular œsophageal opening in the diaphragm and the normal closure of the œsophagus itself obviate the need for such an arrangement.

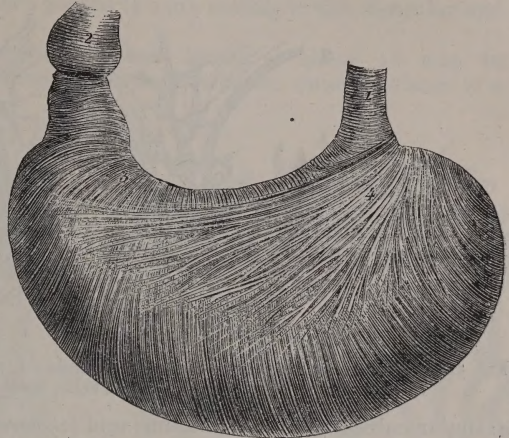


Fig. 520.—Circular and oblique muscular fibres of the stomach, seen from within.

(4) *Submucosa*, a white shining areolar layer, containing a few fat cells, the branchings of the arteries, the dilated beginnings of the veins and the divisions of the nerves. This layer is joined by lax areolar tissue to the

(5) *Mucous layer*, to see which it is advisable to remove the stomach from the body, which may be done by cutting the œsophagus between two ligatures and cutting the duodenum 1 cm. beyond the pylorus, also between two ligatures; before this is done, the student is recommended to note the relations of the upper part of the duodenum as given below (p. 400). The mucous layer of the stomach is a soft, thick, pink, or greyish red stratum, which, not being elastic, becomes rugosely folded when the stomach is not distended. The mucous membrane assumes its characteristic structure at a sharply marked, serrated line at the cardiac orifice where the stratified œsophageal epithelium ends, the deep columnar cells starting suddenly to the surface, and from this the whole surface is invested with a one-layered columnar epithelium whose elongated cells are narrow and granular below and have a superficial mucigenous stratum, without a striated surface-layer. Clusters of small oval replacement cells lie among these near the basement layer. The whole mucosa thins with age, and is normally thinnest at the great bulging end, thickest at the pylorus.



Fig. 521.—Section of the wall of the stomach.

The entire inner surface of the stomach is beset with polygonal pits (*alveoli*) about 0.2 mm. across, the margin of which are often raised into pointed processes like villi. On the floor of each alveolus there appear the round mouths of tubular glands which are packed closely together through the whole

gastric area. Indeed, on section, the wall of the stomach appears to consist of a closely packed layer of vertical gland tubes. There are two kinds of these glands—(1) simple *pyloric glands* (fig. 523), with large deep mouths, lined with epithelium like that of the gastric surface, and short glandular tubules with a

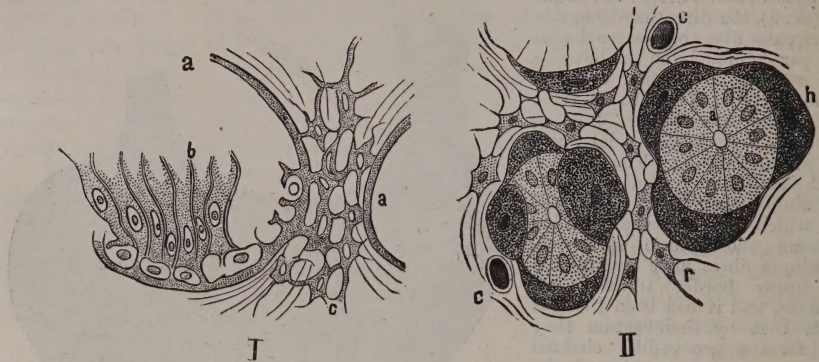


Fig. 522.—Transverse sections of cardiac glands—I, across its duct; II, across its fundus; I, a, membrana propria; b, goblet cells, secreting mucus; II, c, capillaries.

granular cubical gland epithelium; and (2) *cardiac glands* (figs. 522, 524), chiefly present at the cardiac end, with shorter mouths and longer tubules, in which there are two sorts of gland epithelium, *central cells* like those in the pyloric glands, (fig. 522, II, a) and a deeper but not continuous layer of somewhat trigonal, *oxyntic* or *parietal cells* (*ib.*, h), most numerous near the neck of the gland tube and placed with their bases resting on the basement membrane. Of

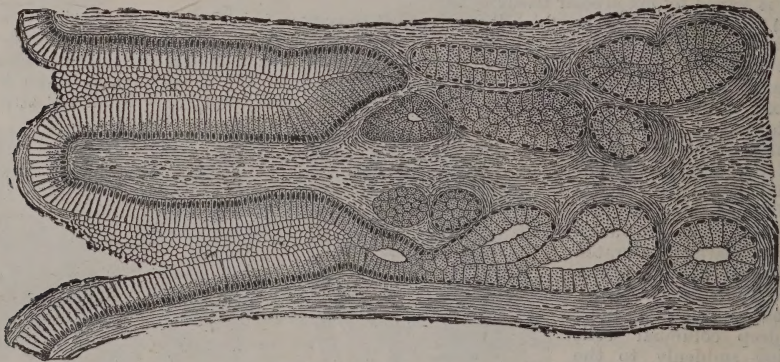


Fig. 523.—Pyloric glands.

these glands there are on an average 100 in a sq. mm., and as the mucous area of the average stomach is 47'500 sq. mms., so there are about four million and three-quarters of these glands.

The epithelium rests on an almost *structureless* basement, under which are connective cells, which send in sustentacular processes between the epithelial cells at their bases to support them (fig. 522, II, r). There is much lymphoid tissue in the corium around the gland tubes (*ib.*, I, c), and a bilaminar *muscularis mucosæ* chiefly of circular fibres, except towards the pylorus, where the outer longitudinal stratum is thicker. Lymph paths are numerous, and communicate with plexiform lymphatics in the submucous layer (fig. 524, d). The blood-vessels (fig. 525) divide into arterioles in the submucosa which run between

the glands to the surface, making a thick superficial capillary plexus, and a deeper interglandular plexus. The venous radicles are fewer and larger.

The vagi enter the stomach-wall on the two sides of the gastric artery, and their branches stream over the stomach from the concave border with the branches of the gastric plexus from the sympathetic (§ 295). These latter form both an Auerbach's and a Meissner's plexus (§ 256), ending in the muscular and mucous layers.

The **pylorus** is a narrow opening, whose lumen is about 16 mm. in diameter, surrounded by a thickened mucous membrane outside which is a

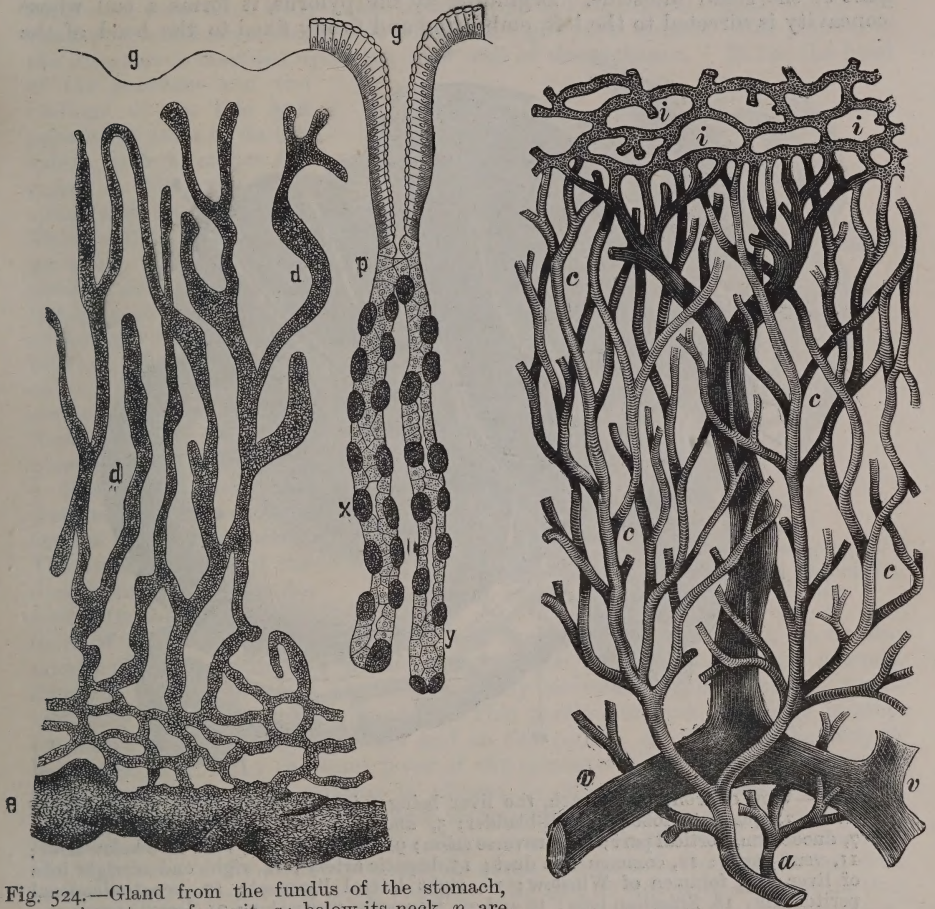


Fig. 524.—Gland from the fundus of the stomach, opening at a surface pit, *g*; below its neck, *p*, are the two sets of cells, the oxyntic cells, *x*; and the central cells, *y*; *d*, lymphatic vessels opening into a large lymphated vessel, *e*.

Fig. 525.—Blood-vessels of gastric wall—*a*, artery; *v*, vein; *c*, capillaries; *i*, network in villous layer.

thick annular bundle of circular fibres which can close the opening. The side towards the stomach is oblique, sloping; that towards the duodenum is abrupt. The hexagonal alveoli of the stomach stop here and the villous intestinal mucosa begins.

The stomach of the foetus is not only proportionally smaller, but is placed nearly vertically, has a very small bulging end, and no appearance of sacculation near the pylorus.

It is separated from the diaphragm by the liver, except for a small space at the cesophagus: In the adult a larger area touches the diaphragm for the most part on a plane leftward of the pericardium, only the extreme left margin of the under wall of the heart being related on opposite sides of the diaphragm to the stomach without the intervention of the liver.

255. THE DUODENUM is that part of the alimentary canal which has been pressed back against the abdominal wall by the passage over it of the primary loop of the intestine, and is consequently fixed to the hinder wall of the cavity by passing through the root of the transverse mesocolon. It is 22 cm. long and 5 cm. in diameter, being thus the widest, as it is the most fixed part of the small intestine. Beginning at the pylorus, it forms a coil whose concavity is directed to the left, embracing and firmly fixed to the head of the

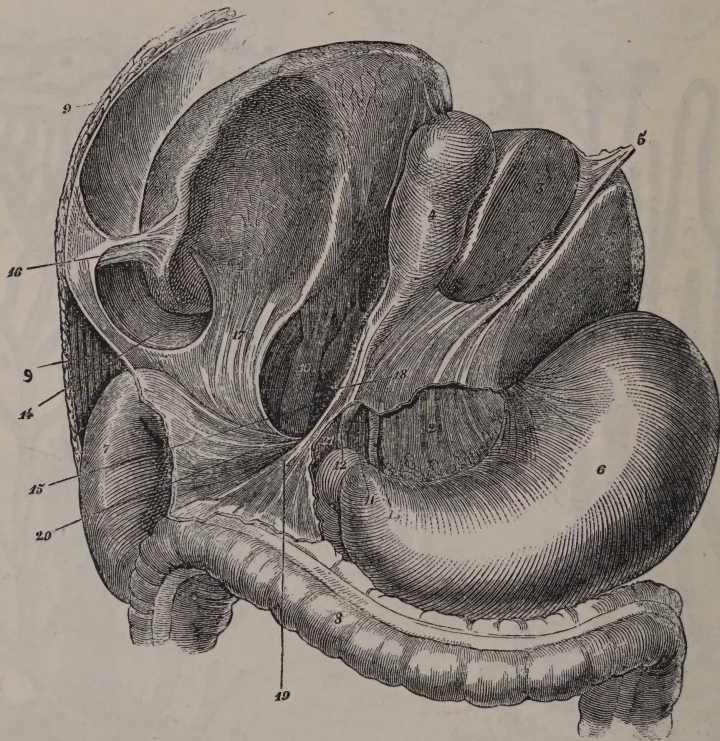


Fig. 526.—View of front of stomach, the liver being raised—1, right lobe; 2, left lobe of liver; 3, quadrate lobe; 4, gall-bladder; 5, umbilical vein, obliterated; 6, stomach; 7, duodenum, vertical part; 8, transverse colon; 9, diaphragm; 10, vena cava below liver; 11, vena portæ; 12, common bile duct; 13, hepatic artery; 14, right end of right lobe of liver; 15, foramen of Winslow; 16, right lateral ligament; 17, hepato-duodenal peritoneum; 18, Spigelian lobe; 19 and 20, transverse mesocolon; 21, lesser omentum.

pancreas. It is divisible into three parts—a *superior*, which ascends backwards and to the right; a *middle*, which descends nearly vertically; and an *inferior*, which ascends at first obliquely and at its end vertically, terminating by turning forwards and to the left, and becoming jejunum at the left side of the second lumbar vertebra.

The superior portion, seen by raising the front edge of the liver and drawing the stomach downwards and to the left, is 5 cm. long, and lies directly below the caudate lobe of the liver and gall-bladder, from which it is separated by the foramen of Winslow. These parts are, however, really in contact before the

abdomen is opened. It is covered in front, above, and for a short distance along its upper and left border by the peritoneum derived from the right extremity of the lesser omentum. This portion is the most movable part of the duodenum, being fixed only by the right pancreatico-gastric fold behind it, and by the head of the pancreas, which lies below it. Behind are the hepatic artery, vena portæ, hepatic duct, and the gastro-duodenal artery. The duodenum turns downwards opposite the neck of the gall-bladder to become continuous with the middle portion.

The second stage (fig. 527, *d*) is 8 cm. long, and passes downwards behind the transverse mesocolon, lying on the right kidney and suprarenal capsule and on the vena cava, which separates it below from the right *psaos* muscle. This portion of the intestine is moulded upon the back wall of the abdomen. It has the head

of the pancreas and the endings of the bile and pancreatic ducts to its left side. In front and to the right is the ascending colon and its mesocolon. This portion is only imperfectly visible in the present dissection, but its upper part can be seen above, and its lower part below, the transverse colon. By dividing the peritoneum above the hepatic angle and displacing the large intestine a little downwards and forwards its whole anterior surface can be exposed. The inferior angle of the duodenum usually descends in the male to the

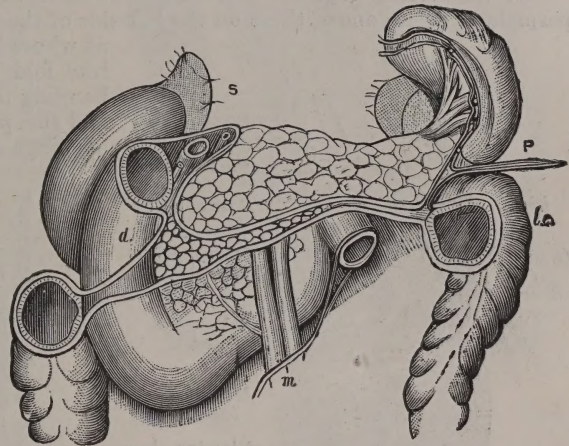


Fig. 527.—View of front of pancreas and duodenum—*P*, cut edge of pleuro-colic fold; *l*, left colon; *d*, duodenum; *m*, mesenteric vessels; *S*, right suprarenal capsule.

level of the disc between the third and fourth lumbar vertebræ, or to the middle of the third lumbar in the female. From this the third stage ascends forwards and to the left, at first obliquely across the spine, then it turns vertically upwards to its termination. This portion is 9 cm. long, and is seen by raising the mesentery upwards and to the right. As it lies in the body it is covered in front by the front layer of the mesentery, the superior mesenteric artery and vein. This relation is altered by raising the mesentery, which artificially lifts up the arteries and brings the lower layer of the mesentery in front of the gut. It lies on the right *psaos* muscle, the vena cava inferior, the right crus of the *diaphragm*, and the aorta, and ends in front of the left crus of the *diaphragm* and left renal vessels. The end of this portion exhibits two peculiar flexures—an abrupt turn upwards on the left of the superior mesenteric artery, and a sharp bend forwards and leftwards (**duodeno-jejunal flexure**) at its termination. A duodeno-jejunal pouch of peritoneum often passes behind the intestine at its termination.

Before proceeding with the dissection of the parts of the intestine, it is usually advantageous to examine the main branches of the superior mesenteric artery. The serous coat of the duodenum is, as has been seen, imperfect, the longitudinal coat of muscular fibres is thick; in the second part some of its fascicles have become entangled in the lobules of the pancreas; at the vertical flexure of the third stage a band of smooth fibres from the wall of the duodenum ascends to the front of the left crus of the *diaphragm* (*suspensorius*)

duodeni) close to the left side of the origin of the cœliac artery. The submucous layer is thick. The underlying mucous membrane may be exhibited by slitting open the gut, *in situ*, and sponging it out (a ligature having been previously put around the beginning of the jejunum; but the examination of the mucous surface may, with advantage, be postponed until the jejunum has been dissected). This membrane for the superior part is thick and vascular, covered by a single layer of columnar epithelium, whose cells have large nuclei and a striated surface layer (§ 22, 1). Between these, at their bases, are reticular processes connected with the connective cells of the basement layer. There are also on its surface many fine processes or villi and many simple, tubular, mucous glands (follicles of Lieberkühn); these are large, about .36 mm. in length. Beside these, there are in the submucous tissue of this portion flat granular patches of racemose glands (**Brunner's glands**) with comparatively narrow ducts, which extend for about 6 cm. from the pylorus, and which in minute structure resemble enlarged pyloric glands; they are largest near the pylorus, and usually disappear in the second stage (fig. 528).

In the second stage the mucous and submucous membrane are raised into permanent rugæ; one of these on the left side of the tube forms a vertical ridge, at whose lower part is a short hood-like fold (**caruncula major**) overhanging the opening of the bile duct and the pancreatic duct. From the openings a vertical fold (**frænulum**

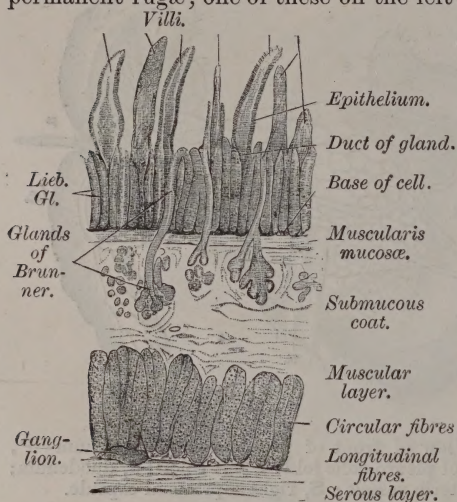


Fig. 528.—Section of duodenum, showing Brunner's glands.



Fig. 529.—Opening of bile and pancreatic ducts into the duodenum.

carunculæ) extends downwards. The ducts take a very oblique course through the intestinal wall (fig. 529).

In the inferior portion these mucous folds have become regularly transverse, crescentic, but never ring-like, projecting for about 7 mm. into the cavity of the gut. These **valvulæ conniventes** are best marked along the anterior wall of the duodenum, are made to project more sharply by distension of the tube, and are covered by villi.

256. SMALL INTESTINE.—The portion of the small intestine which begins at the duodeno-jejunal flexure and extends thence in the free margin of the mesentery to the cæcum is about $6\frac{3}{4}$ metres long, but varies with habits of feeding and heredity, and to some extent with the length of the abdominal cavity, but not at all proportionally to weight, age, or stature; and it is usually a little longer in females than in males. The upper one-third of this intestine is called **jejunum**, and is thicker-coated, larger in calibre, and deeper-coloured than the lower two-thirds or **ileum**; but there is no line of demarcation between these parts, the one shading into the other. All this tube has a continuous coating of serous membrane except at the narrow attached border.

To see the structure of the coats of this intestine isolate about 30 cm. of the upper part of the jejunum, about the same length of the middle part of the intestine, and of the lower part of the ileum, leaving the lowest 20 cm. attached to the cæcum; at each spot the intestine is to be

tied with a double ligature and cut between. The longitudinal muscular coat is thin and continuous, although the fibres form a thicker stratum along the free border than elsewhere. The circular fibres form a continuous layer, and consist of very long, smooth muscle fibres, even longer than the former. The submucosa is dense, areolar, and contains much retiform tissue and many vessels, the mucosa is thick, lined with epithelium-like that of the duodenum, folded for its jejunal part into *valvulae conniventes*, each of which extends for about two-thirds of the circumference, and ends by bifurcating and shading off into the surface. These gradually diminish towards the ileum, and are nearly absent for the lower fourth of the small intestine. Besetting the whole surface are fine filiform, conical, cylindrical, or clavate villi or processes like the pile of velvet (fig. 530). These are about .5 mm. long, and each consists of an outer layer of epithelium, like that of the rest of the intestinal wall, placed on a basement layer, under which are polygonal connective cells, making up the substance of the villus, traversed by blood capillaries (*c*), and with one or two large lymph canals in the axis of the process, beginning blindly near its free end, and at the base communicating with the sub-jacent lymphatic plexus (*b*). The lymph trunk of the villus (*d*) has a muscular investment derived from the muscularis mucosae. Numerous amoeboid lymph cells are found in all parts of the villus.

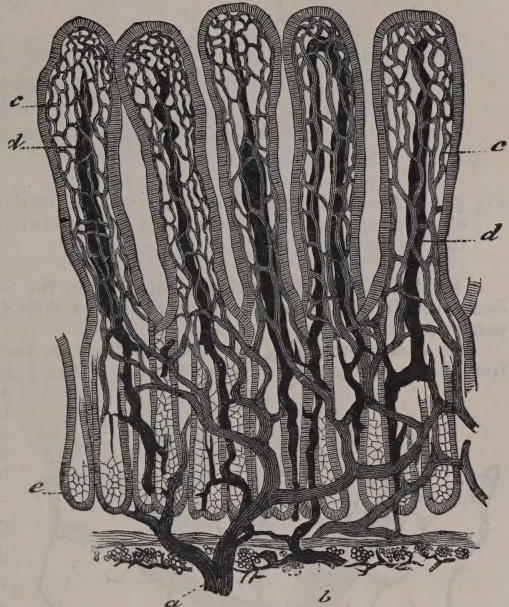


Fig. 530.—Villi of small intestines with the vessels injected.

There are about 16 villi in each square mm. of the upper half of the small intestine, and about 9 per square mm. below, so that altogether there are about four millions of villi in the small intestine. Villi beset both the upper and lower surfaces of the *valvulae conniventes*, which thus not only delay the downward passage of the food but increase the absorbing surface. By the villi the fatty parts of the food are absorbed, the fat particles either (*a*.) being carried into the system by the amoeboid cells, or (*b*.) entering the intercellular reticulum of the epithelium, which is directly continuous with the retiform tissue, or entering the epithelial cells themselves, although these do not communicate with the connective cells or the lymph spaces beneath.

Between the villi are numerous glands of Lieberkühn (fig. 530, *e*), smaller than those in the duodenum. There are also, especially in the lower part of the tube, scattered lymphoid nodules (**solitary glands**), appearing as small specks of encapsulated adenoid tissue, which bulge with a rounded convexity on the surface among the villi, and which appear distinct by being surrounded either by very close-meshed retiform tissue or by a lymph sinus.

In the lower part of the jejunum, and especially in the ileum, there are placed about thirty large, closely aggregated patches of such lymph nodules (**agminated glands or Peyer's patches**—fig. 534). These are small, few, and circular in the jejunum, larger and in longitudinally extended patches on the border of the ileum opposite the mesenteric attachment. Each patch is about 1–3 cm. long by 1–2 cm. wide and is destitute of villi, and may contain from 20–400 lymphoid nodules. They are surrounded by closely-set villi and Lieberkühn's glands. In the intestine of a child there are about forty-five such patches, but they diminish in number and distinctness as age advances, and in old age are only recognisable as patches of discoloration.

Around each lymphoid nodule, solitary or agminated, there is a network both of blood-vessels and of lymphatic capillaries.

In the intestinal wall there are two nerve plexuses—the plexus of Auerbach, between the

longitudinal and circular muscular fibres (fig. 531), and that of Meissner in the submucous tissue (fig. 532). A large-meshed lymphatic plexus accompanies the former. The muscularis mucosæ is thin in the ileum, thicker and bilaminar at the beginning of the jejunum.

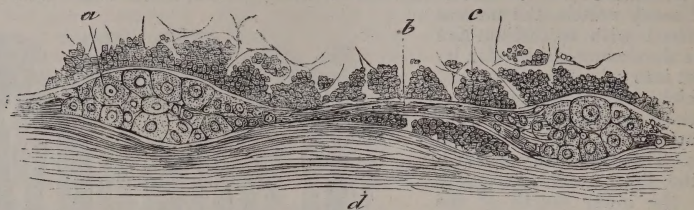


Fig. 531.—Auerbach's plexus, seen in a vertical section of the wall of the jejunum, consisting of—*a*, ganglion; *b*, non-medullated nerve fibre; *c*, circular muscle cut through; *d*, longitudinal fibres. $\times 60$.

The vitelline pedicle which was attached in the foetus to the small intestine at its lower fourth usually leaves no trace, but sometimes a short diverticulum is supposed to represent its persistent extremity.

The arteries supplying the small intestines are the freely communicating branches arising from the convexity of the superior mesenteric (figs. 533, 553), the veins accompany the arteries, and are of large size; the lymph vessels, here called lacteals, are also large, and pass to the lacteal glands in the layers of the mesentery. All these should now be successively examined.

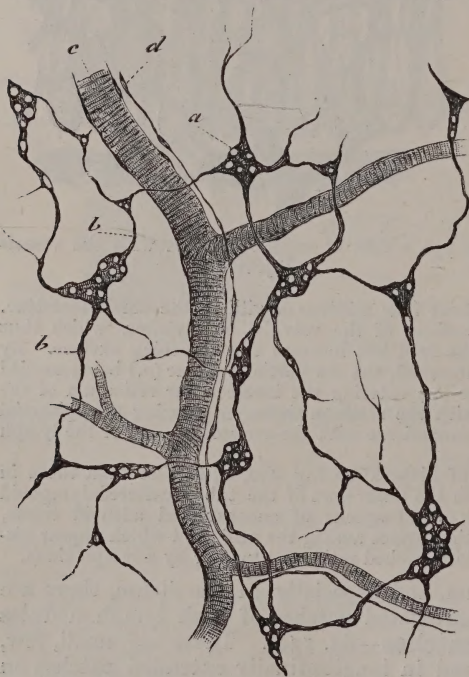


Fig. 532.—Meissner's plexus of nerves in the submucous tissue—*a*, ganglion; *b*, non-medullated nerve; *c*, vessels; *d*, branch of splanchnic nerve system, accompanying the vessel. $\times 50$.

beginning as the cæcum in the right iliac fossa and ending at the anus. Throughout its course it is larger in calibre, thicker in coats and less vascular than the small intestine. Its longitudinal muscular fibres do not form a uniform coat, but are arranged in separate bands, usually three, the *tæniæ coli*, and these being shorter than the underlying coats, its cavity is to some extent sacculated,

The convolutions of the jejunum lie chiefly in the left hypochondriac, left lumbar, and umbilical regions; those of the ileum are chiefly in the left inguinal, lower part of the umbilical and hypogastric regions; the last coil of the ileum lies in the pelvis above the bladder, and rises out of the pelvis to end in the large intestine. During life the intestines are closely pressed together and flattened against each other, their lumina being nearly closed except when distended with alimentary materials or gas.

The remaining parts of the jejunum and ileum may now be removed by the division of the mesentery close to the intestine.

The duodenum should be left *in situ*, indeed it will be advantageous if the examination of its mucous membrane be left until a later stage.

257. THE LARGE INTESTINE is about 1·4 metres in length, and forms a great loop, be-

the **haustra** or pouches being separated by crescentic *plicæ sigmoideæ* (fig. 535) which disappear when the longitudinal fibres are carefully dissected away, and the whole gut then becomes one-sixth longer.

The sacculation of the large intestine has probably arisen coincidently with the consolidation of the faecal masses, and the separation of the longitudinal coat into *tæniæ* is due to the bulging of the haustra thus caused, which, by permitting of greater consolidation and storage of faecal matter, serves to intensify the condition. Its mucous membrane presents no villi nor Peyer's patches, though it has crypts of Lieberkühn larger than those in the small intestine, and solitary lymphoid nodules at the bottom of small depressions in the mucous membrane. It is divisible into three parts—the cæcum, the colon, and the rectum.

The cæcum (fig. 536) is short, about 5.5 cm., and ends at the level of the upper border of the iliac opening; it is the blunt, rounded bulging of the beginning of the large intestine.

In the fœtus the cæcum was an elongated fusiform diverticulum, and at birth it is a long coiled conical portion of the gut tapering to a point, from which begin the three *tæniæ coli* (fig. 538). Very early, however, one or more of these earliest haustra become enormously distended, and the original fusiform fundus becomes small, contracted, and rudimental, so that it appears in the adult as a mere appendix to these dilated basal haustra, to which the name cæcum is usually limited, while the terminal part of the primitive cæcum, which never dilates, now appears as the **vermiform appendix**.

The adult cæcum lies in the right iliac fossa, and is well covered by the peritoneum. The fundus of its most prominent haustra is usually completely covered, and often the peritoneum is invaginated behind it into a **subcæcal pouch**. The vermiform appendix, which lies at the lower, inner, and back part of the newly-formed fundus, has a small mesentery of its own, which ties it to the wall of the rest of the cæcum, and not uncommonly it hangs into the pelvic cavity between the cæcum and the ileum, whose end lies above and in front of it. The peritoneum below

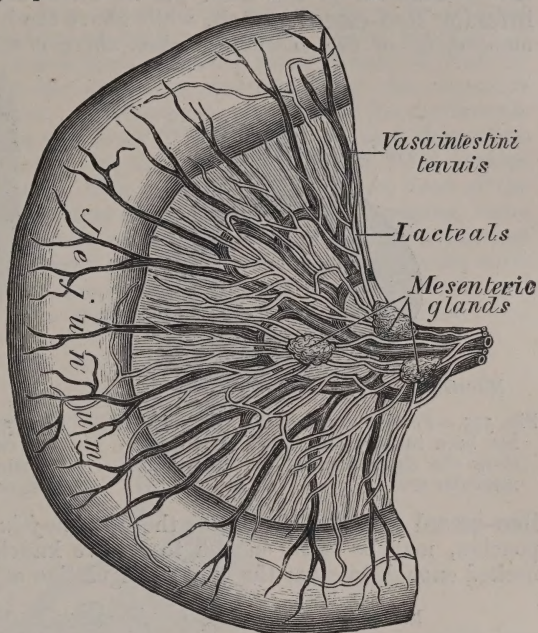


Fig. 533.—Vessels of a loop of small intestine, arteries, and lacteals.



Fig. 534.—Peyer's patch of lymphoid follicles from the ileum, surrounded by solitary follicles.

the termination of the latter gut is often depressed into a narrow-necked **inferior ileo-cæcal pouch**, while above the ileum, between it and the commencement of the ascending colon, there is sometimes a similar **superior**

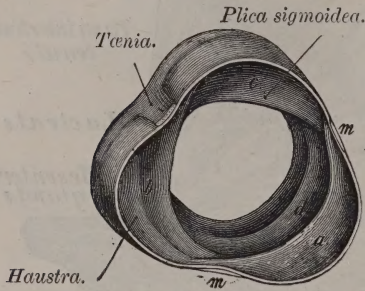


Fig. 535.—Portion of transverse colon which has been inflated and dried, cut open to show the sigmoid plicæ—m, longitudinal muscular tenia.

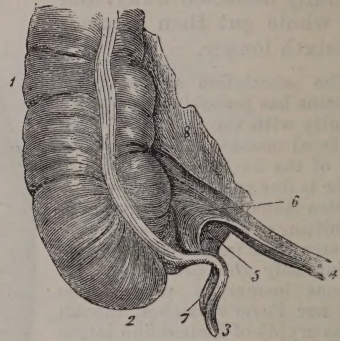


Fig. 536.—Cæcum—1, ascending colon; 2, cæcum; 3, vermiform appendix; 4, ileum; 5, inferior ileo-cæcal pouch; 6, its anterior serous wall; 7, mesenterium.

ileo-cæcal pouch; these, like the *duodeno-jejunal* and other retroperitoneal pouches, may be large enough to receive knuckles of intestine, and narrow-necked enough to cause the fatal strangulation of such knuckles.

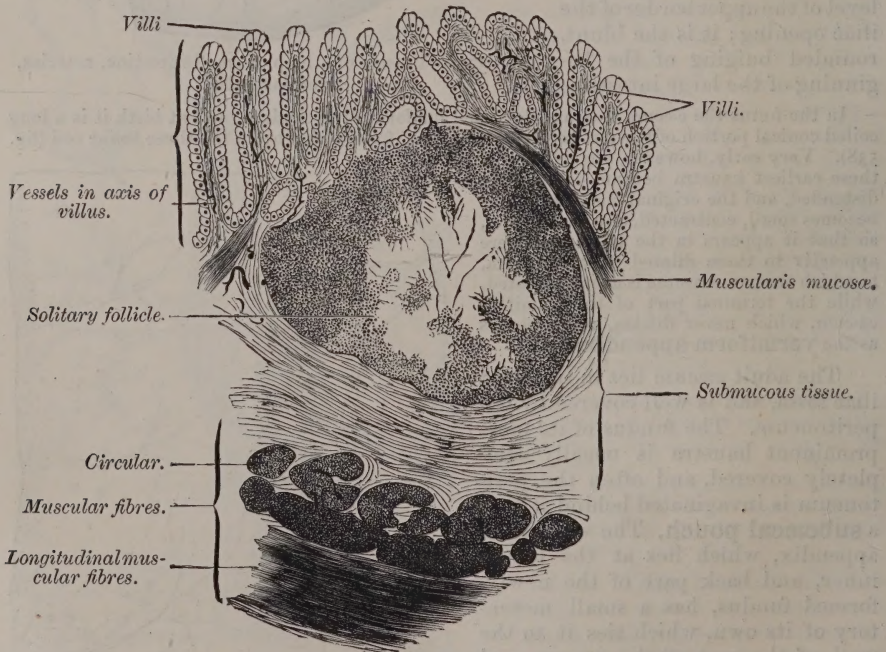


Fig. 537.—Solitary follicle of colon.

From the cæcum the ascending colon passes upwards in the right lumbar region as far as the lower surface of the liver. This is, from its course and from the effects of gravity, the widest part of the large intestine, having usually at its

commencement a circumference of 25 cm. It is usually bent in its course, towards the median line. It is only covered with peritoneum on its anterior and lateral surface, a large portion of its hinder aspect being generally in contact with the back wall of the abdomen, especially below, where it joins the cæcum. This has given rise to the erroneous statement that the cæcum is imperfectly covered by peritoneum. The border of reflection of the peritoneum below the colon is usually above the level of the cæcum, so that there is no mesocæcum present in most cases, while the two layers of the right lumbar mesocolon are usually widely apart. The ascending colon lies in front of the *psoas*, kidney, and duodenum; it becomes displaced outwards in stooping, being more prominently displaced by change of position than any other portion of the intestinal canal, but in the upright position the kidney bulges to its outer side. At its upper extremity it becomes better covered with peritoneum, and its hepatic flexure grooves the lower surface of the right lobe of the liver.

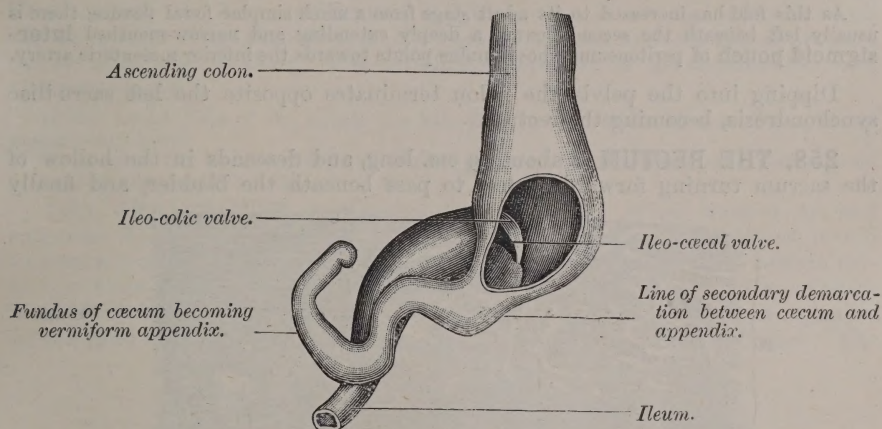


Fig. 538.—Fœtal cæcum.

The **transverse colon** begins at the hepatic flexure and passes for a short distance to the right in front of the duodenum, from which it lifts off the peritoneum, here entering the right end of the ascending layers of the great omentum. The transverse colon is usually thrice as long as the line between its two hypochondriac flexures, and is, therefore, sinuously bent. From the right it passes at first leftward, then forwards, then it bends downwards towards the umbilicus behind the apron of the great omentum, and beginning now to appear more pendent from its under surface. It makes here one or two sharp bends and then ascends to the left to end in the splenic flexure close to the hinder part of the eleventh rib, to which it is tied by a thin-edged fold of peritoneum, the **pleuro-colic fold** (fig. 527).

The transverse colon is usually unequal in calibre, and is well covered by peritoneum, receiving at its anterior edge the omental layers which separate from it posteriorly, as the transverse mesocolon (p. 392). Along its omental edge is the strong **omental tænia**, along its mesocolic edge is the **mesocolic tænia**, and between and below it the third or **free tænia**, along the sides of which, corresponding to the sigmoid folds within, the peritoneum hangs down in little fat-holding fringe-like processes, the **appendices epiploicæ**. In this portion also the circular fibres are stronger than elsewhere, and its down-hanging loops about the umbilicus are the common seats of colicky spasms (*tormina*).

From the splenic flexure in the left hypochondrium, the **descending colon**

passes down in the left lumbar region. This is longer, narrower, and much more movable than the ascending, is well covered by peritoneum, and has a narrow linear area of mesocolic reflection; hence in the operation of making an artificial anus, it is much easier to find the unclad area of the ascending colon in the right lumbar region than to strike upon the non-peritoneal area of the left colon. It usually lies to the outer side of the left kidney.

In the left iliac fossa the colon presents another area of elongation, and has become bent into its **sigmoid flexure**, a double curvature whose first or anterior part is a loop concave upwards and backwards, while the hinder part is a loop downwards and forwards. This and the loop of the transverse colon are proportionally larger in the female than in the male, and are intensified by, and themselves reciprocally intensify, a constipated habit of bowel. A large part of the former loop projects to the surface in the left iliac fossa, and can be felt, especially when distended with feces.

As this fold has increased to its adult stage from a much simpler foetal flexure, there is usually left beneath the second flexure a deeply extending and narrow-mouthed **inter-sigmoid pouch** of peritoneum, whose fundus points towards the inferior mesenteric artery.

Dipping into the pelvis the colon terminates opposite the left sacro-iliac synchondrosis, becoming the rectum.

258. THE RECTUM is about 19 cm. long, and descends in the hollow of the sacrum turning forwards below to pass beneath the bladder, and finally



Fig. 539.—Structure of lower end of the rectum—I, skin-covered area of anus; II, transitional area; III, mucous area; 1, 2, columns of Morgagni; 7, superficial sphincter; 4, deep sphincter; 6, skin; 5, limits of external sphincter; 8, plexus of varicose anal veins.

turning downwards below the tip of the coccyx to end at the anus. It differs from the rest of the large intestine in that the tæniæ become confluent on it into two thick, wide, but not very clearly margined bands, anterior and posterior, the former (*m. prærectalis*) being the very strong confluence of the omental and free tænia of the colon. It does not present an appearance of external sacculation, and is only covered with peritoneum on its anterior and lateral (especially its right) surfaces. For its lower half the peritoneum of the recto-vesical cul de sac simply invests its anterior surface, while it is posteriorly in contact with the pelvic wall. The termination of the rectum has already been seen in the dissection of the perineum (p. 354).

The ileum and ascending colon having been tied with double ligatures, each about 6 inches from the cæcum, these intestines are to be cut between the ligatures and the cæcum removed, wash out the gut by passing a stream of water first through the ileum, which will easily flow through, and secondly, through the colon, which usually will not, until the pressure becomes excessive. Inflate then the gut from the ileum and examine its coats; having done this, open the cæcum through the bulging part of the fundus below the iliac orifice which then appears like a button-hole slit with two nearly parallel margins, the upper one forming a nearly horizontal shelf, the **ileo-colic valve**, the lower one being an obliquely ascending fold, the **ileo-cæcal valve**; from the union of these valves in front and behind a prominent fold, the **frænum of Morgagni**, passes round the cæcum as a shelf. Each valve is a duplication of the mucous, submucous, and circular muscular layers, and by careful division of the serous and longitudinal fibres they can be unfolded. The mucous surface of the valves towards the ileum are villous, the cæcal surface is smooth.

The valves can be most easily seen by drying an inflated cæcum and then cutting a hole in the middle of the fundus of the chief haustrum.

259. THE VERMIFORM APPENDIX (fig. 538) is very variable, usually about 6-10 cm. long and 1 cm. in diameter, and is generally cylindroid and blunt ended. It has a continuous longitudinal and circular muscular coat, and its mucous membrane is rich in lymphoid follicles and sometimes presents one or more mucous folds. The vermiform appendix is the degenerated long ancestral cæcum.

In the lowest fossa of the cæcum the hair-thread worm, *trichocephalus dispar*, is not uncommonly found.

To examine the haustra, take out similar pieces of the transverse colon and sigmoid flexure and examine their coats.

260. THE RECTUM is best examined *in situ*. When washed out and examined from below, especially with the body on its hands and knees, it will be seen when the anus is dilated with a speculum that there are certain permanent folds of the mucous membrane visible (Houston's valves). One of these is on the left and hinder side of the gut, about 3 cm. above the anus, and a second is on the right and rather in front, about 6 cm. from the orifice. The

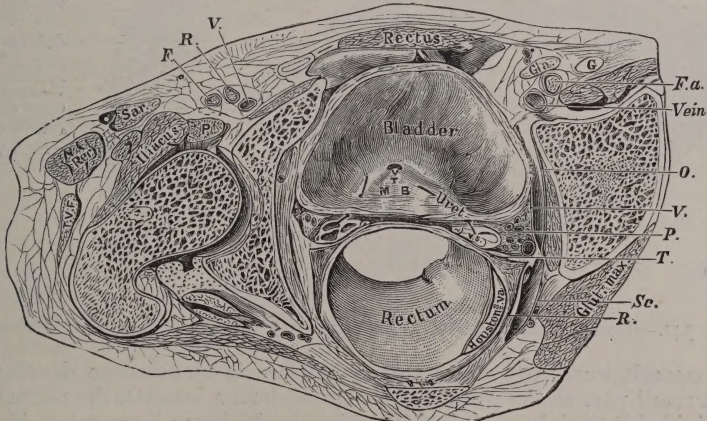


Fig. 540.—Nearly horizontal section of pelvis through the left acetabulum and below the right, showing the rectum and Houston's valve. In this body the rectum was distended with feces when frozen. For other references see § 303.

second is the more prominent and often projects as a broad shelf, but can be obliterated by cutting the *m. prærectalis*, which here wrinkles the gut. The dilatation below the second fold is the *ampulla analis*. It bulges forwards, and gives the anus the appearance of being bent backwards.

The ischio-rectal fossa should now be opened and the superficial sphincter ani removed. Beneath it the circular muscular fibres of the lower portion of

the gut are seen to be thickened and to form a strong engirdling ring, the deep sphincter ani, about 6 mm. from the cutaneous orifice. The circular fibres are fairly uniform from this upwards, but sometimes thicken a little, 12 cm. above the anus. The longitudinal fibres descend outside these and are lost in the connective tissues around the anus.

The upper thickening of circular fibres, when present, constitutes the sphincter tertius.

Detach the *levator ani* muscle on one side from the lower end of the intestine and draw the gut forwards; a band of unstriped but reddish muscle can be found passing to each side of the rectum from the second coccygeal vertebra, forming a *recto-coccygeus* muscle, which is lost in the lower part of the longitudinal musculature behind.

The mucosa of the lower part of the rectum is thick and vertically folded. The folds are 7-14 mm. long and 5-8 in number (**Columnæ recti** of **Morgagni**, fig. 539), and contain a thickened muscularis mucosæ and descend to the anus, which in section appears as an opening with a linear stellate lumen (fig. 596). The muscularis mucosæ is 0.2 mm. thick in the lower third of the rectum though only 0.03 thick in the colon. There are no glands in the mucosa at the anus, and the columnar epithelium ends in a narrow zone of transitional epithelium, becoming stratified and scaly at a wavy line.

The vessels around the anus, instead of ending in a plexus in the submucosa, pass in parallel lines towards the anus in the mucosa, and are joined by crossing branches.

261. LIVER.—The position and peritoneal relations of the liver have been already noted (pp. 386, 392), but should now be reviewed and the ligaments re-examined. The round ligament may be cut about an inch from the edge of the liver.

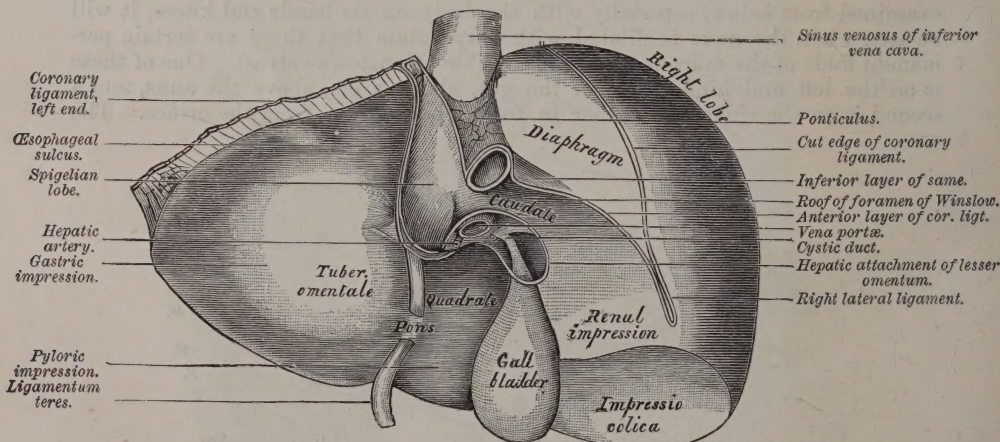


Fig. 541.—Under surface of liver as it appears when removed from a frozen body.

The smooth, unequally convex upper surface is moulded to the diaphragm and to a small part of the front wall of the abdomen beneath the metasternum, and is divided into right and left lobes by the falciform ligament. Along this line and to the left is a shallow depression, corresponding to the heart. The anterior or thin edge of the liver presents two notches, one opposite the cartilage of the ninth rib for the fundus of the gall-bladder, and one nearer the median line for the obliterated umbilical vein.

The inferior surface of the liver is irregular, divided into five lobes, *right*, *left*, *quadrate*, *Spigelian*, and *caudate*, by five fissures, which are arranged like a capital **V**, the crossbar being the **transverse fissure**; the two foremost sagittal lines being respectively, a fissure for the gall-bladder to the right and for the umbilical vein to the left. The hinder continuations of these are for

the vena cava to the right and for the ductus venosus to the left. The under surfaces of the left and quadrate lobes are concave where they rest upon the stomach. The inferior surface of the right lobe is concave anteriorly for the hepatic flexure of the colon and posteriorly for the upper surface of the right kidney, and close to the middle of the gall-bladder is impressed by the first part of the duodenum, behind which the lobus caudatus is facietted for the pancreas. Posteriorly the liver comes in contact with the diaphragm and the hinder wall of the abdomen by a narrow **posterior surface** separated from the upper surface by the upper line of reflection of the peritoneum of the coronary ligament, and from the lower on the right side by the lower line of reflection, and on the left side by a prominent knob of the left lobe (**tuber omentale**), behind the left end of the transverse fissure and by lines drawn therefrom to the left extremity and to the peritoneal reflection on the vena cava. When the liver is removed and its vessels emptied, the distinction between this surface and the inferior becomes obsolete. The posterior surface is deeply notched in the middle for the vertebral column and is indented by the inferior vena cava, which is sunk into the hepatic substance. To the right of the vena cava under cover of the lower border of the coronary ligament, the liver is facietted by the right suprarenal capsule. To the left of the vena cava is the vertical hinder surface of the Spigelian lobe, leftward of which the posterior surface of the left lobe is vertically grooved by the œsophagus. The lower surface of the caudate lobe forms the upper boundary of the foramen of Winslow, and the lower end of the Spigelian lobe projects as a rounded eminence (**tuber papillare**) to form the roof of the upper omental sac.

The liver rises and falls with the diaphragm in breathing, the dome-like top of the right lobe rising in forced expiration as high as the horizon of the upper border of the eighth dorsal vertebra, while in forced inspiration it descends to the plane of the upper edge of the ninth dorsal. The position of the organ likewise varies with posture. In the standing position in the adult, the edge of the liver corresponds to the lower edge of the right costal cartilages as far as the seventh, crosses about 2 cm. below the metasternum, and extends 4 cm. beyond the median line to the left. This border is lower in young persons and in females. In the recumbent position on the back, the liver gravitates backwards, the lower border passing at least 1 cm. above the lower edge of the ribs. In the attitude of lying on the face the liver gravitates about 1 cm. forwards, and when the body is placed on the side there is a certain amount of lateral slide permitted by the ligaments and vessels whereby the organ is fixed. The ligaments cannot be made quite tense, but in each position some one or other of them is to some extent stretched. The habitual use of a tightly-laced corset displaces the liver downwards, in extreme cases even into the iliac fossa. The size, and to some extent the shape, of the liver are liable to considerable changes during healthy life. The organ is temporarily diminished in size during fasting, permanently in old age.

These relations of the liver and the course of its vessels should be studied while the liver is in place.

Lift up the front edge of the gland and trace the vessels which enter and leave the liver at the transverse fissure. These are—(1) the hepatic artery, which lies in front and to the left (§ 271); (2) the common bile duct, to the right; and (3) the vena portæ, which lies behind and between these (§ 294). Along the hepatic artery the hepatic plexus of nerves should be traced (§ 295), and between the artery and the vein are the hepatic lymphatics (§ 295).

The **common bile duct** appears near the right end of the transverse fissure formed by the union of two ducts, the **cystic**, which is the continuation of the tapering end of the gall-bladder, and the **hepatic**, which arises in the transverse fissure. The latter is formed by the junction of two ducts, right

and left, which emerge from the hepatic substance in the transverse fissure. The common bile duct (**ductus communis choledochus**) descends in the lesser omentum in front of the vena portæ and to the right of the hepatic artery and its gastro-duodenal branch. It enters the right pancreatico-gastric fold (p. 390) behind the first part of the duodenum, and is crossed by the pancreatico-duodenal artery as it approaches and pierces the second part of the duodenum about the middle of its second stage (§ 255). It pierces through the coats of the duodenum very obliquely, above the point where the greater pancreatic duct enters, but the two ducts unite before they pierce the mucous membrane, which they usually do by a small common orifice, which is most easily found by passing a probe downwards through the duct (fig. 529).

The union is sometimes pathologically dilated into a small sac (**diverticulum Vateri**). The common bile duct appears stained through with bile; but this, like the staining of the viscera around the gall-bladder, takes place after death. The duct consists of:—

1. A thick areolar adventitious coat.
2. A layer of longitudinal unstriated muscle, under which is an indefinite and imperfect layer of circular fibres.
3. A firm, nearly bilaminar corium, consisting of an outer coarse areolar tissue, containing a close-meshed capillary plexus and an inner delicate basement layer. Long branching racemose glands pierce this through the whole extent of the duct.
4. A high columnar epithelium with the peculiar striated surface layer of intestinal epithelium (p. 23). The whole duct is about 65 mm. long.

Divide the remaining part of the lesser omentum containing the vessels about 2 cm. below the transverse fissure, and by removing the peritoneum, which forms the hinder wall of the foramen of Winslow, expose the vena cava inferior below the gland. Divide this vessel both here and above the liver. The liver is to be removed from the body by drawing it downwards, and cutting the remaining parts of the peritoneal ligaments, and dividing the connective tissue, which unites the hinder surface of the right lobe to the diaphragm, between the layers of the coronary ligament.

The liver is the heaviest organ in the body, weighing in the adult male about 1,830 grammes, or, when its vessels are filled with water, about 1,970 grammes. Its volume is about 1,530 cm., its specific gravity 1.065, and it forms about $\frac{1}{10}$ of the weight of the male body, about $\frac{1}{8}$ of that of the female, $\frac{1}{11}$ of the weight of the fœtus at birth, and $\frac{1}{10}$ of the weight of the fourth month fœtus. In the unnaturally flattened position assumed by the liver when laid on the table it measures 28 cm. in length, 19 cm. in breadth at its widest part, and 6 cm. in thickness at its thickest (right) part.

The student should now review the attachments of the ligaments, the boundaries of the several lobes, and the points of entry of the several vessels on its lower surface. The left and quadrate lobe will be seen to be united by a bridge (*pons hepatis*) which may be either a delicate membranous shred or a thick bridge of gland tissue; beneath it the obliterated umbilical vein passes to join the left branch of the vena portæ at the left end of the transverse fissure. In the posterior limb of the longitudinal fissure, a fine white cord, the obliterated ductus venosus, arising from the left branch of the vena portæ opposite the end of the umbilical vein, can be traced backward to join the left hepatic branch of the vena cava. The Spigelian lobe projects behind the transverse fissure, and the caudate appears as a narrow isthmus joining it to the right lobe in front of the vena cava.

In colour the liver is reddish-brown, in texture firm but brittle, softer during life than after death; hence, violent blows upon the abdomen may rupture the liver, when the soft parts over it only show comparatively slight marks of contusion.

The liver is invested (1) imperfectly with peritoneum, deficient (*a*) between the layers of the coronary ligament, and (*b*) above the gall-bladder; (2) under the peritoneum is a thin, firm, elastic areolar investment, visible where the peritoneum is absent, inseparable from the serous layer elsewhere. This forms sheaths around the vessels entering at the transverse fissure, which are called the **capsule of Glisson**.

Into the vena cava at the back of the liver there pass three large branches,

the *venæ cavæ hepaticæ*, returning the blood from the organ. If one of these be slit open, it will be seen to be made up by the union of many smaller branches, which are called **sublobular** veins. These vessels are so closely tied to the surrounding liver substance that, if cut across, the lumen remains open. The liver substance consists of minute polyhedral lobules, each about 1-2 mm. in diameter, and imperfectly marked off from each other, clustered around the sublobular vein upon which their bases rest. In the axis of each lobule there runs a fine vessel, the **intralobular** vein (fig. 543, V.c) which begins in the middle of each lobule and pierces the centre of its base to empty itself into the sublobular vein (*ib.*, V.s).

Each lobule consists of hepatic cells and vessels. The hepatic cells which build up the great bulk of the organ are polygonal epithelial cells about 40μ in diameter without definite walls, and consequently amoeboid during life, and with one or two rounded nuclei, a distinct intracellular network with a few pigment specks and oil globules (fig. 542). These cells are closely packed together in the lobules whose shapes are determined by the arrangement of the blood-vessels, as the lobules in the human liver have no connective capsules, but become confluent where they are not separated by vessels.

Entering the liver at the transverse fissure are the right and left branches of the *vena portæ*, each of these carries with it a thickened connective prolongation of the areolar investment of the liver, the capsule of Glisson, which also invests the branches of the hepatic artery and hepatic duct, indeed the branches of the artery, duct, and *venæ portæ* run together enveloped in prolongations of this sheath as far as the lobules. The branches of each as they run side by side included in the common connective envelope are called **vaginal** branches. In sections through the liver, cut branches of the *vena portæ* may be distinguished from those of the *vena cava* by their being accompanied by an artery and a duct, as well as by the investing capsule. Lymph vessels, lymph spaces, and nerves also lie in the processes of the capsule of Glisson.

From the vaginal branches of the *vena portæ* there arise **interlobular** branches which pass between the hepatic lobules, and by their anastomoses form networks around each lobular clump of hepatic cells. These interlobular veins are surrounded by a very delicate connective tissue, and send in **lobular** branches which form a close centripetal capillary network with elongated meshes in the hepatic cells of the lobule, discharging their blood into the central **intralobular vein**.

The area in each lobule around the central vein (the hepatic vein zone) is liable to pigment changes and is darkest. The peripheral or portal area is liable to fatty degeneration, the intermediate (or arterial zone) to amyloid disease. The delicate connective tissue around the minute vessels proliferates in the gin-drinker's liver, causing the characteristically modulated appearance. The blood capillaries run along the interspaces between the angles of contiguous cells, and each is in contact with several cells at each plane of section.

The branches of the hepatic artery are much smaller than those of the *vena portæ*. They give off (1) capsular branches, which supply not only the connective tissue of Glisson's capsule but also the investing areolar capsule of the surface of the organ; (2) interlobular branches break up into capillaries outside and around the lobule, supplying the walls of the portal veins and of the ducts, and ending in two areas. (A) In some places, as on the surface of the liver, these capillaries can be seen uniting into minute venous radicles, which sometimes appear stellate (the inner roots of the portal veins), which again subdivide and directly



Fig. 542.—Hepatic cells—*b*, oil globules; *c*, young cell; *d*, border of contact with capillary.

join the lobular capillary plexus of the vena portæ. (B) It is difficult to trace direct anastomoses of the arterial and portal capillaries, but such have been seen near the periphery of the lobules. The arterial capillaries are very fine and cannot be injected except through the artery directly.

The bile duct capillaries begin as apparently wall-less channels usually between the sides not the angles of contiguous cells. Into these there appear to pass minute intercellular channels, starting from vacuoles in the neighbouring cells. These capillary ducts which form a network of channels around each cell unite into minute lobular ducts, which appear at first to have a homogeneous

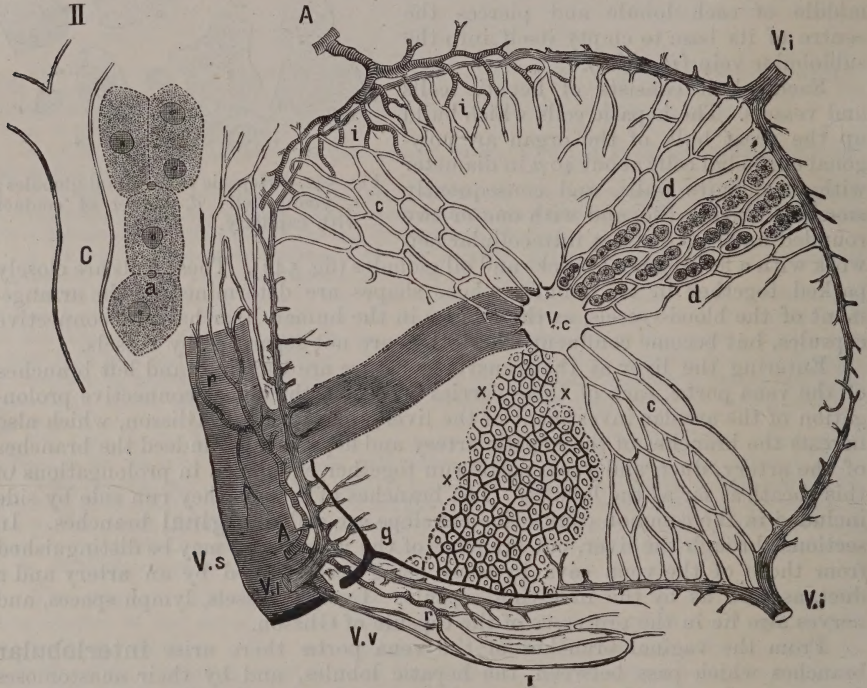


Fig. 543.—Scheme of hepatic lobule—V.c being the central intralobular vein passing into the sublobular vein (V.s); V.i, interlobular branch of portal vein; c, capillaries in lobule; A, hepatic artery giving off interlobular and lobular branches, as well as branches to the capsule of Glisson (r) and vasa vasorum to the large veins, the blood from these returns by the venæ vascularis (i) into the intralobular vein; g, lobular branches of the bile duct, beginning by intercellular passages between the bile cells at x. The position of the hepatic cells between the capillaries is shown at d. II, isolated hepatic cells beside a capillary. x 300.

wall, and escaping from the lobule these unite to form ducts; these, uniting, form the larger vaginal ducts which traverse the portal canals, and ultimately form the right and left trunks, which emerge at the transverse fissure. The larger ducts resemble the common bile duct in structure but have a richer supply of branched racemose gland follicles in their walls.

The branches of the hepatic plexus of nerves (§ 295) travel in the portal canals, and consist for the most part of non-medullated fibres, together with a few double-contoured nerves, probably derived from the right vagus. They enter the liver in two series, one (the principal) around the arteries, the other around the ducts, a very few lying on the walls of the vena portæ. The nerves of the liver are remarkably small in size in proportion to the size of the organ.

They form minute ganglia on the arterial walls. The nerve endings are not known; most of the filaments are lost in the walls of the vessels, but some seem to form an interlobular plexus from which fine intercellular branches are prolonged to end on the surface of the hepatic cells. Filaments of the right phrenic not only pass directly into the surface of the right lobe at the coronary area, but also pass through the phrenic ganglion of the sympathetic (§ 295).

The hepatic lymphatics are proportionally numerous, and are arranged in two sets. The sub-peritoneal series form a superficial network of large branches with few valves, and communicate with the lymphatics of the diaphragm and anterior mediastinum through the falciform ligament by six or seven trunks. Those of the left lobe pass in the left lateral ligament to join the cesophageal lymphatics at the diaphragm. Most of the superficial lymphatics pass to the transverse fissure and there communicate with the three small lymphatic glands in front of the vena portæ in the lesser omentum. The deep lymphatics begin as perivascular spaces between the lobules and as lymph spaces in the shreds of interlobular connective tissue. They pass out in the portal canals close to the branches of the vena portæ, joining the superficial lymphatics in the transverse fissure.

262. THE GALL-BLADDER (figs. 526, 541), best seen when moderately inflated through its duct, is a pear-shaped sac about 10 cm. long, 3 cm. in diameter at its widest end, and capable of holding about 20 c.cm. (21 grms.) of bile. It lies in the groove between the right and quadrate lobes, and consists of fundus, body, and neck. The **fundus** is covered with peritoneum, directed forwards, and touches the abdominal wall below the front end of the cartilage of the right ninth rib. The **body** is clothed with peritoneum below, and lies over the hepatic end of the transverse colon, the pyloric end of stomach and the beginning of the duodenum; above, it is closely tied by areolar tissue to the under surface of the liver. The **neck** narrows backwards, and, becoming bent into an S-like fold, ends at the transverse fissure of the liver by becoming the cystic duct, through which alone its cavity communicates with the other tubes of the liver.

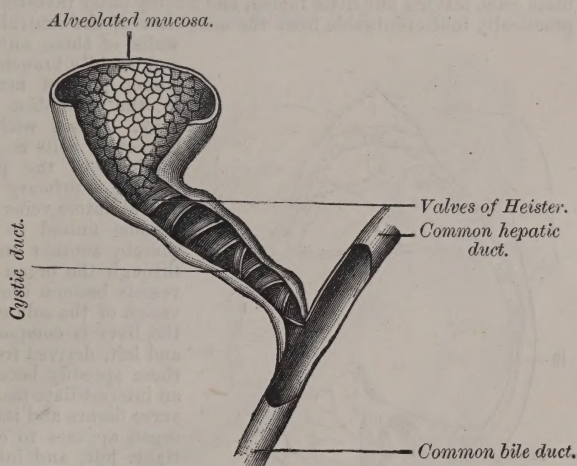


Fig. 544.—Gall-bladder and ducts cut open, showing valvular folds.

In the erect posture of the body the fundus of the gall-bladder is its lowest part, so the bile naturally flows hereinto when the stomach is undistended. From the lower surface of the neck the free border of the lesser omentum descends as a fold either to the duodenum or colon (fig. 526, 19).

Beneath the outer imperfect coating of peritoneum of the gall-bladder is the **middle coat** of dense areolar tissue containing smooth muscular fibres, both longitudinal (mostly at the fundus) and circular (mostly at the neck), but these do not form separate strata.

Branches of the cystic artery ramify in this layer, each accompanied by two veins which ultimately join either (A) branches of the vena portæ at the transverse fissure, or (B) the superior pancreatico-duodenal vein. The cystic branches of the hepatic plexus of nerves also subdivide in this layer, and bipolar ganglion cells are often found in the angles of division of its filaments.

The **mucous membrane** shown by opening the sac is irregularly depressed into minute honeycomb-like pits, separated by sharp ridges, which become more prominent when the vessels are minutely injected. At the neck of the sac these ridges become modified into seven or eight successive oblique folds which, taken together, appear as a screw-like valve (**valves of Heister**), thereby the ingress and egress of the bile is made slower, but is not stopped.

The mucous membrane has a distinct muscularis mucosæ, and its high columnar epithelium has a striated surface layer like that in the intestine. Near the neck of the bladder there are large saccular glands like those in the common bile duct. The cystic duct is about 2 cm. long, and sinuously curved as far as its junction with the hepatic duct.

263. THE LEFT LATERAL LIGAMENT contains between its layers minute net-like branches of the vena portæ, hepatic artery and duct, the traces of a rudimental lobe. A similar plexus exists in the bridge of tissue which passes at the back of the vena cava from the hinder surface of the Spigelian to that of the right lobe (**ponticulus hepatis**).

264. DEVELOPMENT.—The liver is the earliest of the abdominal organs to differentiate, appearing in the second week as a pair of diverticula from the digestive tube below the stomach (fig. 29). These extend into the septum transversum towards the heart, having between them the vein of the hypoblast (vena portæ). They consist of a thick lining layer of hypoblast cells, leaving but little lumen, and a thick outer investment of mesoblast which becomes practically indiscriminable from the mesoblast of the ventral mesentery. From the cellular

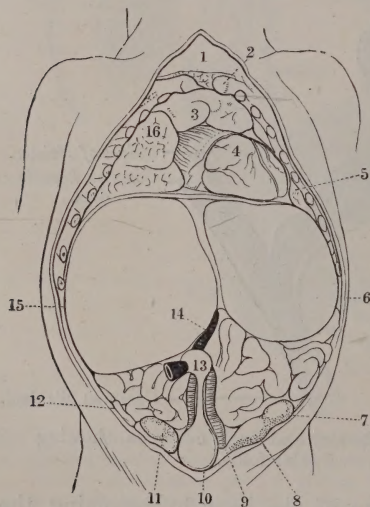


Fig. 545. — Fœtal abdomen opened, showing the great size of the liver—1, thyroid; 2, clavicles; 3, thymus; 4, heart; 5, left lung; 6, left lobe of liver; 7, undescended testis; 8, gubernaculum; 9, umbilical arteries; 10, bladder ureter; (13), urachus; 14, umbilical vein; 15, right lobe of liver; 16, right lung.

walls of these outgrowths there arise numerous and rapidly branching columns of hypoblast cells, which form a network of solid cellular cords, in the mesoblast of whose interspaces vessels arise. Along with these and between the solid masses of cells so arising, branching tubular extensions of the primitive diverticula develop, making a primary system of ducts for the organ. The allantoic veins which were at first prehepatic become united to the vena portæ below it, and thereby another and larger stream of blood is sent through the organ stimulating its growth; these vessels become broken up into a rete by the invasion of the columns of hypoblast cells. At first the liver is composed of two separate parts right and left, derived from the primary diverticula, but these speedily become united by the formation of an intermediate mass, developed behind the transverse fissure and its vessels. When thus fused the organ appears to consist of three primary lobes—right, left, and inferior. The latter expands on each side of the vena cava, that on the right becoming the Spigelian, that on the left the caudate lobe, but in man the latter early coalesces with the right lobe, although traces of its primitive distinctness are occasionally present. One of the primitive diverticula on the inferior part of the right lobe dilates and becomes saccular, forming the gall-bladder, the gland cells round it atrophying. The quadrate is only a subdivision of the right lobe.

The liver rapidly enlarges from the second to the seventh week, being at the end of the second month one-third the weight of the body, and beginning to secrete at the end of the third month. At the fifth month it is one-seventh of the body-weight, and at the eighth is one-twentieth. The right lobe even at first is a little larger than the

left, at birth they are to each other as 1 : 1.6, but in the adult they are as 1 : 4.5. As the liver grows, the wall of the primitive intestine joining the two primary processes of out-growth becomes elongated and forms the duct, whose cavity is largely formed by diacelosis.

The vasa aberrantia of the ponticulus, left lateral ligament, and gall-bladder wall are traces of lobules which have atrophied.

Anastomoses between the hepatic and parietal vessels are very few even at its diaphragmatic area of contact, hence, as local superficial depletion cannot relieve congestion of the

liver, it has been an old practice, based on the observed frequency of piles in liver disease, to deplete the liver by leeching the verge of the anus, and so drawing blood from the intestinal veins.

265. THE PANCREAS is a compound racemose gland (fig. 546), of a pinkish cream-colour and soft texture, lying across the first lumbar vertebra on the hinder wall of the abdomen, behind the stomach and between the celiac axis above and the superior mesenteric artery, which it overlaps, below.

It can be seen in the present dissection as the stomach has been already removed, but in a fresh abdomen it can be shown most easily by dividing the great omentum below the stomach and raising that viscus.

It consists of a large right end, the **head**, a middle part or **body**, and a left end or **tail**. In its natural place it is moulded to the surrounding organs, and is consequently very irregular, but anterior and posterior surfaces can be recognised as well as a thin upper and a thicker lower edge. When removed from the body it appears as a long flat organ somewhat like a dog's tongue. The head is closely attached to the concavity of the loop of the duodenum, which it fills, its upper border projecting towards the foramen of Winslow as a rounded boss, the **tuber omentale**, its posterior surface is grooved by the common bile duct and lies on the inferior vena cava, and its lower part descends to the level of the right side of the second lumbar vertebra, or even lower, following the duodenal loop. At the junction of the head and the body the superior mesenteric artery and vein pass behind the gland, the left edge of whose head is hooked around the latter so that the vein lies in a deep gutter or channel in the gland, the reflected border passing quite behind the vein, but not behind the artery (fig. 546, *m*.) The body lies upon the aorta, the splenic vein (which grooves it), the termination of the inferior mesenteric vein, the left crus of the diaphragm, and the left suprarenal capsule; the tail of the pancreas lies on the left kidney and its vessels, and its left end is in contact with the spleen. The lower border of the body and tail lies above the third part of the duodenum, is tilted forwards by the superior mesenteric vessels medially, and lies on the root of the mesocolon and on the beginning of the descending colon. The peritoneum of the hinder wall of the lower omental sac lies in front of it, but the amount of covering depends on the width of the opening between the two pancreatico-gastric folds which are attached to its upper edge (§ 251), while the celiac axis grooves it in the middle above, and the splenic artery runs tortuously to the left along its upper border above its vein. The extremity of the tail of the pancreas projects into the parieto-splenic ligament of peritoneum.

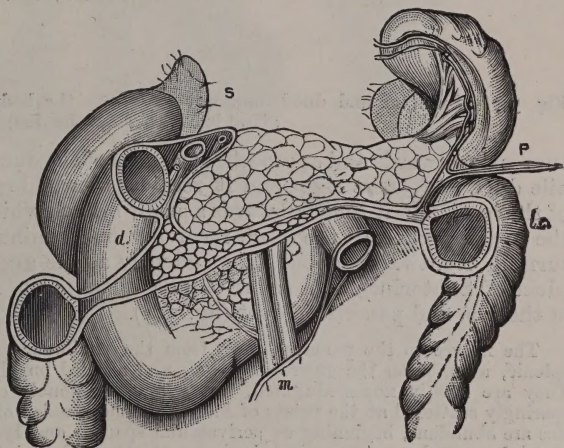


Fig. 546.—Pancreas *in situ*, shown by dividing and removing the transverse colon and mesocolon and the stomach.

The pancreas has an indefinite areolar capsule which sends in processes around its lobules, and vessels enter it at many points along its border. Above and to the right it receives

branches from the *pancreatico-duodenalis superior* (p. 422), and below from the *pancreatico-duodenalis inferior* (p. 423), while to the left it receives the *pancreatica magna* and *pancreaticæ parvæ* from the splenic.

266. THE PANCREATIC DUCT (of Wirsung) can be shown by scraping through the front of the gland; it begins in the middle of the thickness of the pancreas near its tail, and passes horizontally rightward not quite in the middle of the organ, but a little nearer its lower and back part (fig. 547). It is a thin-walled white tube, 2 mm. in diameter, and receives from the different lobules of the gland numerous branches which pass into it at right angles. Eventually it

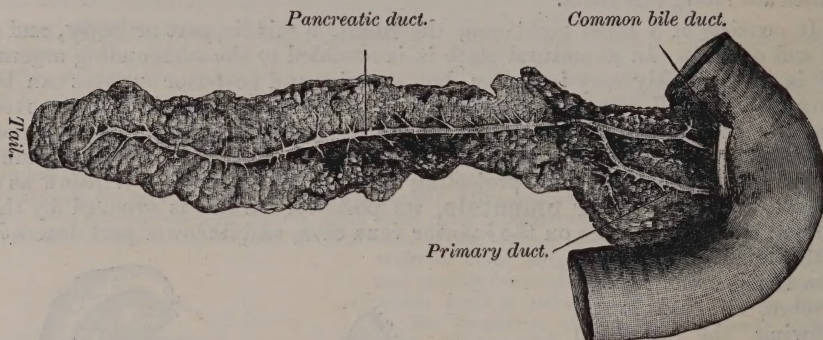


Fig. 547.—Pancreas and duodenum removed from the body and seen from behind. The gland is cut to show the ducts.

curves downwards and approaches the wall of the duodenum in company with the bile duct. Near its right end it receives a large branch from the lower lobules of the head, and it sends upwards a small branch which ascends in a loop through the upper portion of the head, receiving many minute branches. This branch, turning rightwards, opens independently as the **accessory pancreatic duct** (duct of Santorini), on a small papilla about 4 cm. above the common opening of the bile and pancreatic duct (fig. 529).

The nerves to the pancreas come from the semilunar ganglia in three sets, one on the splenic, another on the gastro-duodenal, and a third on the superior mesenteric arteries. They are mostly non-medullated, but a few are double contoured. Ganglion cells are sparingly scattered at the points of branching and reunion of the nerve plexuses. Lymphatics are abundant, beginning as perivascular spaces; and lymphoid nodules lie between the glandular pouches. These lymphatics empty themselves into two glands which lie on the superior mesenteric artery.

In structure the pancreas is a compound racemose gland divisible into primary, secondary, and tertiary lobules which are united by lax areolar tissue.



Fig. 548.—Section of fresh pancreas.

The chief ducts are lined by unstriated columnar epithelium, and they commence in *intercalary ducts* lined by flattened epithelium. These arise from the terminal alveoli which are tubular, often convoluted, and with a very small lumen, into which spindle-shaped central cells (**centro-acinar cells**) project, continuous with the epithelium of the intercalary ducts. The secreting cells are broadly columnar, having an inner granular part next the lumen, an outer clear and faintly striated part next the basement, and an intermediate nucleus. Fine intercellular canaliculi appear to exist between the cells. Glomeruli of lymph cells, with minute vascular tufts, intervene between the alveoli.

The whole gland is about 18 cm. long, 4 cm. broad, and 1.5 cm. thick. Its weight is about 75 grammes and its bulk about 65 cubic centimetres. The duct of the pancreas has a number of simple or racemose gland follicles in its wall.

The pancreatic secretion after death softens the textures about the lower and back parts of the gland, hence the pancreatico-duodenal arteries are very liable to give way during the injection of a body which has been several days dead.

Development.—The pancreas begins as a tubular outgrowth from the back of the intestine below the stomach and behind the biliary diverticula (fig. 29). This appears at the end of the fourth week and extends by the growth and division of the fundus of the projection. A second diverticulum projects a little above the first, and soon fuses with it making the upper part of the head of the pancreas. The primitive tubules of outgrowth become the permanent ducts (p. 15).

267. THE ABDOMINAL AORTA (fig. 549) begins where the thoracic aorta (§ 213) ends at the twelfth dorsal vertebra, and descends thence on the front of the bodies of the vertebræ, and a little to the left of the middle line. On

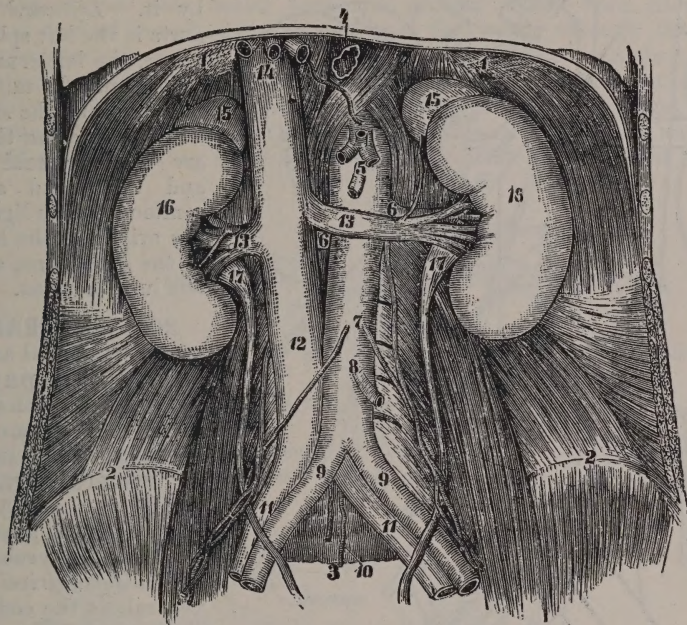


Fig. 549.—Abdominal aorta.

reaching the intervertebral disc between the fourth and fifth lumbar vertebræ, it gives off the two common iliacs (*ib.*, 9), and suddenly diminishes in size, being continued along the middle of the sacrum under the name of the **middle sacral artery** (*ib.*, 3). This vessel extends to the front of the coccyx, where it is called the **middle coccygeal artery**, and terminally pierces the floor of the pelvis to end in the coccygeal glomerulus (§ 220).

These parts, however, for convenience, may be considered separately, and the name, abdominal aorta, is usually limited to the supra-iliac part, which is 15 cm. long and 21 mm. in diameter at its beginning, 17 mm. at its end.

Relation.—It is covered from above downwards by the middle arcuated ligament of the diaphragm, the right lobe of the liver, the solar plexus around the celiac artery, the lesser omentum, œsophagus and stomach, pancreas, ascending layer of the transverse mesocolon, third part of the duodenum, left renal vein (*ib.*, 13) and origin of the vena portæ, transverse mesocolon and its

descending layer (forming the root of the mesentery and attached to the small intestines), and the aortic plexus of nerves.

To its *right side* lies the inferior vena cava (12), which above is on a plane anterior to it, but below is on a plane posterior. On a plane between the artery and vein are the right crus of the diaphragm, the Spigelian lobe of the liver, the right great splanchnic nerve, the commencement of the vena azygos, and thoracic duct; below, the vein is close to the artery and overlapped by it. *Leftward* of the aorta is the left splanchnic nerve, the left crus of the diaphragm, the tail of the pancreas, and the small intestines. *Behind* the aorta are the vertebral bodies and discs and anterior commonspinous ligaments, the origin of the left crus of the diaphragm, and the left lumbar veins.

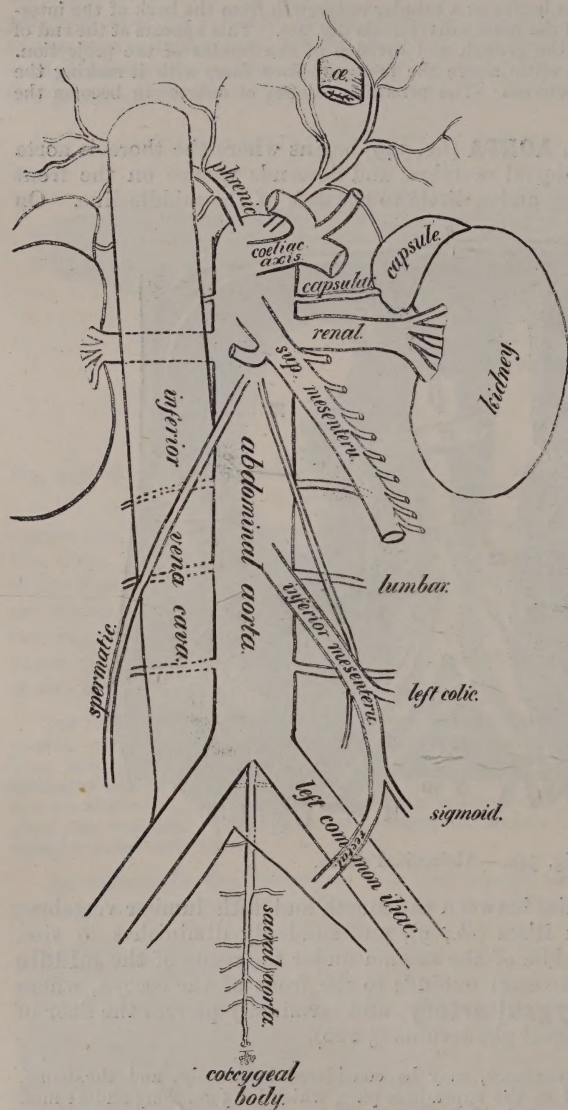


Fig. 550.—Scheme of branches of abdominal aorta.

268. THE BRANCHES

of the abdominal aorta are twofold, (1) **parietal branches**, which are bilaterally symmetrical, phrenics and lumbar; (2) **visceral branches**, which may be (A.) *symmetrical*, as the suprarenal, renal, and spermatic; or (B.) *unsymmetrical* medio-ventral, as the coeliac and the two mesenteric arteries. In order from above downwards these branches are (1) phrenic; (2) suprarenal; (3) coeliac; (4) first lumbar; (5) renal; (6) second lumbar; (7) superior mesenteric; (8) spermatics; (9) third lumbar; (10) inferior mesenterics; (11) fourth lumbar; (12) common iliacs.

269. THE PHRENIC

ARTERIES are two, arising from the front of the aorta as it enters the abdomen. The right passes between the middle and the right leaflets of the tendon of the diaphragm, behind and to the left of the vena cava, to supply the muscular part of the diaphragm; it gives off (1) a *lateral branch*

to the costal part of the muscle; (2) a *central* branch to the border of the central tendon; (3) a *branch to the caval opening*; (4) several small *hepatic capsular branches*; (5) the *right superior suprarenal branch*. The left phrenic separates the aortic from the œsophageal opening of the *diaphragm*, and sends *lateral* and *central* branches, like those of the right, as well as *œsophageal* and *suprarenal* branches. Along the border of the muscles they anastomose with the six lower intercostal and the internal mammary arteries.

270. THE LUMBAR ARTERIES are four pairs, which pass out at right angles from the hinder surface of the aorta, one on each side of each vertebra close to the disc, each vessel runs outwards and a little downwards around the side of the body of the vertebra, the first and second pair behind the crura of the *diaphragm* and *psaos* muscles, supplying the muscles which border them, by branches which pass under tendinous arches. Each then divides into *dorsal* and *ventral* branches, the former pass backwards through the *anterior* and *posterior intertransverse* muscles (p. 258) and *quadratus lumborum* to end in the deep surface of the *erector spine*, and to send branches outwards into the regions of the abdominal muscles. The anterior branches pass in front of the *quadratus lumborum* to the adipose capsule of the kidney and to the abdominal muscles. They anastomose with each other and with the renal and

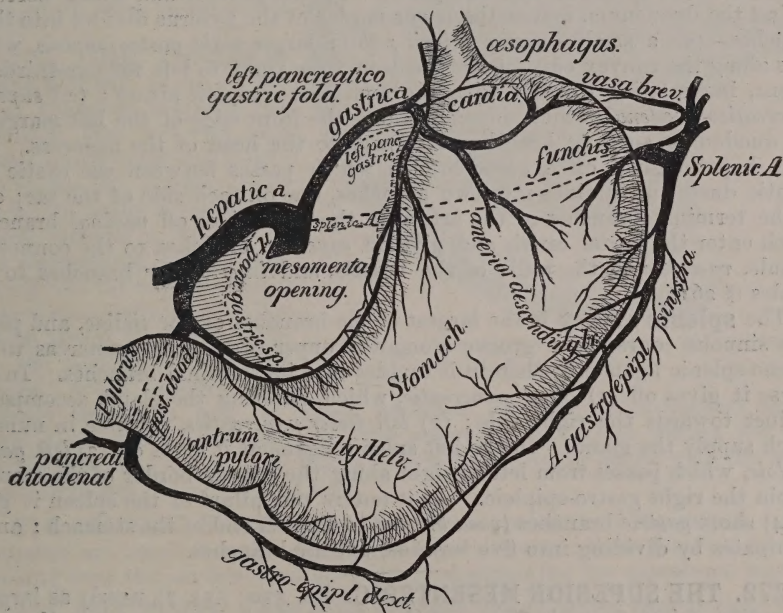


Fig. 551.—Branches of the celiac artery.

epigastric and circumflex iliac arteries and with the lumbar branch of the ilio-lumbar artery (§ 279). The upper anastomose with the subcostal (p. 347), the lower posterior branches descend in the *gluteus maximus*, and the lower anterior in the iliacus in front of the ilium; and they anastomose with the gluteal and circumflex iliac arteries respectively.

271. THE CÆLIAC ARTERY (figs. 550, 551) is a short ventral branch passing sagittally forward above the pancreas, behind the lesser omentum, having the right lobe of the liver above and the semilunar ganglia, one on each side. It

divides into three branches, a right or hepatic, upper left or gastric, and a lower left or splenic.

The **gastric artery** ascends behind the hinder layer of the upper omental sac of peritoneum, and turns forwards to the right of the œsophagus into the left pancreatico-gastric fold and thereby into the lesser omentum. It is continued along the concave edge of the stomach to terminate at the antrum pylori by anastomosing with the superior pyloric artery. Its branches are two *inferior œsophageal* which ascend on that tube (p. 395), two *cardiac* branches which encircle the cardiac orifice of the stomach, the *great anterior gastric* which crosses the anterior surface of the stomach to the great cul de sac, a series of *lesser anterior* and *posterior gastrics* which cross the stomach towards the convex border.

The **hepatic artery**, larger than the last, passes upwards and to the right behind the back wall of the omental sac as far as the upper edge of the duodenum. It passes forwards to the base of the right pancreatico-gastric fold to enter the right edge of the lesser omentum in which it ascends to the transverse fissure of the liver, here it terminates by dividing into *right* and *left* branches. On its way to the pancreatico-gastric fold it gives off (1) the right *lesser pancreatic* branch to that gland; (2) the *superior pyloric*, which runs along the upper edge of the antrum pylori to join the gastric; (3) *gastro-duodenal*, which descends behind the duodenum, and at the lower border of the pylorus divides into three branches—(a.) a small *inferior pyloric*; (b.) a larger *right gastro-epiploic*, which runs along the convex edge of the stomach from right to left for two-thirds its extent, inosculating directly with the left gastro-epiploic artery; (c.) *superior pancreatico-duodenal*, which descends along the front edge of the left margin of the duodenum, sending branches to it and to the head of the pancreas. The right hepatic gives off a *cystic* branch which passes between the cystic and hepatic ducts and divides into two branches, one on each side of the sac; each of the terminal branches of the artery in the liver gives off *vaginal* branches, which enter the portal canals and give off *capsular* branches to the connective capsule, *vascular* to the walls of the vessels, and *interlobular* branches to the lobules (§ 261).

The **splenic artery** is the largest of the branches of the cœliac, and passes in a sinuous course in a groove along the upper edge of the pancreas to the phreno-splenic ligament, wherein it divides into its terminal branches. In this course it gives off (1) *great pancreatic*, which, entering the gland, accompanies its duct towards the right side; (2) *left lesser pancreatics*, variable in number, which supply the gland. In the left splenic ligament it gives off (3) *left gastro-epiploic*, which passes from left to right along the convex border of the stomach to join the right gastro-epiploic. As it enters the hilum of the spleen it gives off (4) short *gastric* branches (*vasa brevia*) to the left end of the stomach; and it terminates by dividing into five terminal splenic branches.

272. THE SUPERIOR MESENTERIC (figs. 550; 553, 7), nearly as large as the cœliac, arises from the front of the aorta behind the pancreas, and crosses the third or ascending portion of the duodenum. It enters the mesentery and descends therein, sending, behind the peritoneum, branches rightward to the ascending colon. The artery is curved convexly to the left, and gives off from its convexity about nine jejunal and seven iliac branches, which pass in the mesentery to the small intestines; each of these bifurcates after a short course, the branches joining by inosculation those above and below them. From the arches thus formed secondary smaller but more numerous branches arise. These form *secondary arches*, and from these the terminal branches to the intestine arise and each divides into two—one to the front, the other to the back of the intestine, to which they thus give a large constant and uniform supply.

From the concavity of the superior mesenteric there arise (1) the *inferior pancreatico-duodenal*, which passes rightwards between the third part of the duodenum and the head of the pancreas, supplying the latter; (2) the *colica media* (fig. 553, 11), which passes in the transverse mesocolon to the transverse colon. This branch divides as do the other intestinal arteries; its right branch anastomoses with the right colic, its left with the left colic. (3) The *right colic* (*ib.*, 10) arises below the last and passes into the right lumbar mesocolon wherein it divides into an ascending branch which unites with the right branch of the middle colic, and a descending which joins the terminal branch of the artery; (4) the *terminal* branch is indistinguishable from the other iliac branches, except in its supplying the cæcum as well, it is hence called *ileo-colic*, and sends an artery to the vermiform appendix.

In the fœtus the omphalo-mesenteric, which vanishes in the third month, was a branch of this trunk.

273. THE INFERIOR MESENTERIC

arises about 3 cm. above the origin of the common iliac arteries and passes downwards and to the left in the left lumbar mesocolon; it sends upwards (1) *colica sinistra*, a branch to the descending colon, bifurcating like the rest, its upper branch anastomosing with the *colica media*, its lower with (2) the *sigmoid artery*; this second trunk enters the sigmoid mesocolon, and its upper branches join the *colica sinistra* and its lower the succeeding artery; (3) the *superior rectal* which enters the mesorectum and descends on it to supply the rectum, joining below with the middle rectal branches of the internal iliac.

274. MIDDLE SUPRARENALS.—The uppermost of the paired visceral branches are small branches arising a short distance above the first lumbar, crossing over the aortico-renal ganglion, and supplying the suprarenal capsule.

275. THE RENAL ARTERIES are large vessels which pass at right angles from the sides of the aorta on the level of the first lumbar vertebra to the kidneys; they cross the crura of the diaphragm, the right passing also over the inferior vena cava. As each renal artery approaches the hilum of the kidney it divides into three or four branches, the uppermost of which is the *inferior suprarenal*, passing to the suprarenal body, the others enter the sinus of the kidney and give off (1) *adipose* arteries to the fatty capsule, and (2) *interpyramidal* branches which enter the organ in which their distribution has been already described. An *inferior renal artery* arising from the aorta on the level of the inferior mesenteric, and passing horizontally outwards to the lower end of the sinus of the kidney, is so common as scarcely to constitute an anomaly.

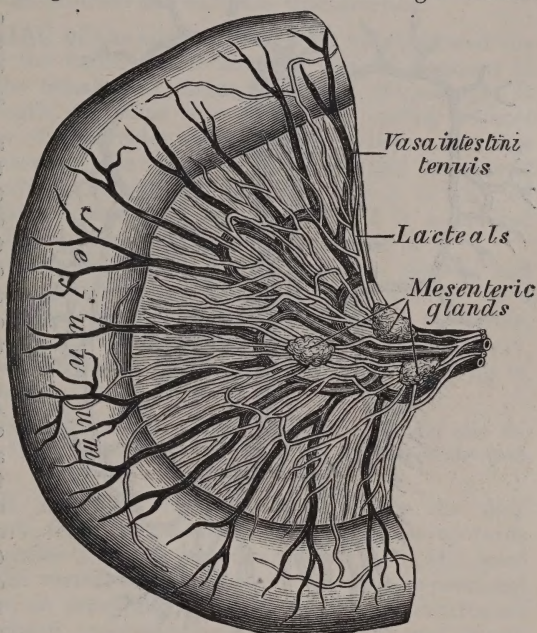


Fig. 552.—Branches of mesenteric vessels passing to a loop of jejunum.

276. THE SPERMATIC ARTERIES arise from the *front* of the aorta below the renals, and like them the vessels of the two sides are not always on the same level; descending outwards each crosses the aortic plexus and psoas muscle and lies behind the peritoneum and ureter, with which it enters the iliac fossa, and to which it sends small branches. Descending thence in front of the psoas over the genito-crural nerve it meets with the vas deferens (§ 304)

at the deep abdominal ring (§ 243), and with it descends on the spermatic cord (§ 246) to the testis, on which it divides into epididymal and glandular branches.

In the female each spermatic artery crosses the psoas and the common iliac artery inwards to enter the broad ligament of the uterus, and is distributed to the ovary and ovarian end of the Fallopian tube. Below the kidney each artery gives off an inferior adipose artery to the fat of that region.

277. THE COMMON ILIAC ARTERIES are the last pair of branches arising from the aorta as it contracts to become the middle sacral, and they diverge from each other at an angle of 60° in the male and 68° in the female. The right common iliac artery is about 11 mm. in diameter, and passes downwards and outwards to bifurcate opposite the upper edge of the sacro-iliac synchondrosis. It is about 5 cm. long and lies under cover of the peritoneum; it is crossed at its termination by the ureter, medially by the last coil of

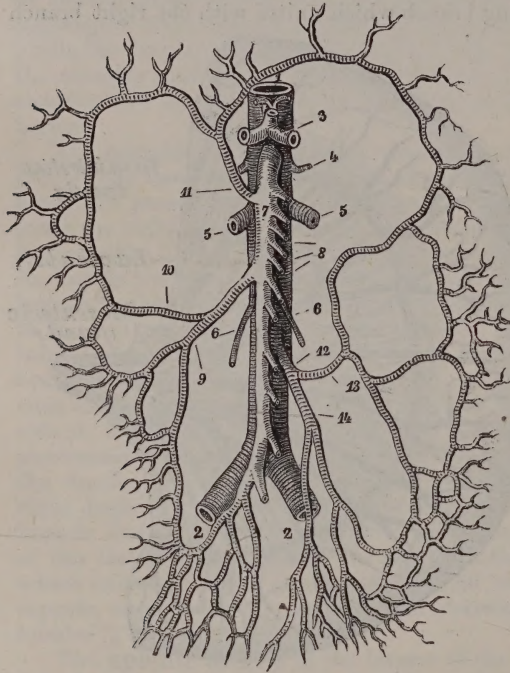


Fig. 553.—Branchings of the mesenteric arteries—1, the aorta; 2, common iliac arteries; 3, coeliac artery; 4, suprarenals; 5, renals; 6, spermatics; 7, superior mesenteric; 8, vasa intestini tenuis; 9, ileo-colic; 10, colica dextra; 11, colica media; 12, inferior mesenteric; 13, colica sinistra; 14, arteria sigmoidea and superior rectal.

the ileum and the attachment of its mesentery, by the terminal branches of the superior mesenteric artery, and the branches of the sympathetic nerve passing from the aortic to the hypogastric plexus. It lies on the end of the left common iliac vein, on its own vein and the beginning of the inferior vena cava. These separate it from the spine, psoas, and sympathetic, but it touches the psoas at its lower end. In the groove between the two former lie hidden the obturator nerve, the ilio-lumbar artery, and the lumbo-sacral nerve.

The left common iliac artery averages 4 cm. long and 11·2 mm. in diameter. It descends under cover of the peritoneum, the sigmoid colon and its mesocolon, the superior rectal artery, the sympathetic branches passing to the hypogastric plexus, and, usually, the ureter at its bifurcation. The artery lies on the fourth and fifth lumbar vertebræ, the psoas muscle, and the sympathetic nerve, and at its termination upon its own vein.

In the angle of divergence between the common iliacs the promontory of the sacrum pro-

jects, on which lie the sacral aorta, the left common iliac vein, and the hypogastric plexus of the sympathetic nerve.

The common iliacs give off minute *peritoneal*, *ureteric*, and *sub-peritoneal* branches; these are seldom large enough to admit of injection, but they communicate with the wide-meshed plexiform arrangement of small sub-peritoneal vessels derived from the lumbar, renal, and phrenic arteries, which make such an important extra-peritoneal anastomosis. The two end-branches into which each common iliac divides are the internal and external iliac arteries.

278. THE INTERNAL ILIAC of the adult is the vessel which formed the root of the allantoic artery of the fœtus. It is about 8 mm. in diameter in the male, about 8·2 mm. in the female, but increases during pregnancy. It measures about 3·5 cm. in length, and dips into the pelvis, ending a short distance above the upper border of the greater sciatic notch. It lies on the edge of the *psaos* muscle, the obturator and the lumbo-sacral nerves and the side of the sacrum close to the synchondrosis, *beneath* the peritoneum as it is reflected backwards from the posterior false ligament of the bladder, and it is crossed near its origin by the ureter. Its vein lies behind and external to it.

The adult internal iliac artery gives off two sets of branches, *parietal* and *visceral*. These usually arise in two sets—an *anterior*, often arising by a common trunk, and consisting of hypogastric, vesical, middle rectal, obturator, pudic, and sciatic arteries, and a *posterior* set, which usually arise separately, and are the gluteal, ilio-lumbar, and lateral sacral; the mode of grouping is, however, inconstant and immaterial.

The fœtal internal iliac artery is larger than the external, and does not dip into the pelvis, but is directly continued into the hypogastric trunk, and varies but little in size from its origin to the umbilicus.

279. THE ILIO-LUMBAR ARTERY usually arises, before the final breaking up of the parent trunk, from its posterior side, and turns upwards and outwards between the obturator and the lumbo-sacral nerves in the space between the *psaos* muscle and the vertebral column. Above the ilio-pectineal line it divides into two branches, an ascending or *lumbar*, which is distributed to the *psaos* and its neighbourhood, anastomosing with the third and fourth lumbar arteries, and usually sending off the spinal branch in the lumbo-sacral foramen.

The outer or *iliac* branch passes beneath the *psaos* and anterior crural nerve, lies at first on, and then under the *iliacus*. It gives off (1) a nutrient branch to the ilium; (2) a descending branch, which crosses the iliac fossa to join a branch of the circumflex iliac; (3) an external branch, which skirts the iliac crest to join the circumflex iliac; and (4) an ascending branch, which joins the last lumbar artery.

280. THE LATERAL SACRAL BRANCHES are generally two on each side, which descend inwards and cross the upper slip of the *pyriformis* and the first sacral nerve outside the sympathetic chain. The uppermost enters the first sacral foramen, the lower descends over the *pyriformis* and sacral plexus, and sends branches through the second, third, and fourth foramina. Each branch sends off a small muscular branch to the *pyriformis* and sacral plexus, and a visceral branch passing forwards to the rectum; the terminal branches entering the foramina to supply the contents of the spinal canal, communicating with the anterior spinal artery and with the coccygeal branch of the sciatic artery.

281. GLUTEAL ARTERY.—The largest branch of the internal iliac arises directly above the greater sciatic notch, and passes backwards in the interspace between the lumbo-sacral nerve above and the first sacral nerve below, through

the upper part of the notch, close to the bone, a tendinous arch of the pelvic fascia being stretched below it. On emerging posteriorly beneath the *gluteus maximus*, it divides into two branches, a superficial and a deep. The former lies on the posterior iliac tubercle, below the oblique gluteal line, and enters the *gluteus maximus*; an anterior branch, which pierces the front and upper border of this muscle close to the iliac crest, anastomoses with the deep circumflex iliac artery. The deep branch passes between the *gluteus medius* and *minimus* to be distributed as described below (§ 322), giving off an external nutrient branch to the ilium.

Within the pelvis the gluteal gives off branches to the *pyriformis*, *obturator internus*, and *levator ani* muscles.

282. THE HYPOGASTRIC was the continued trunk of the internal iliac in the fœtus, and is the foremost of the branches which usually form the anterior series. It passes forwards into the lateral false ligament of the bladder, where it is crossed by the vas deferens, and ascends to the upper and front part of the bladder, to which it sends several small branches. Beyond this point the artery is not pervious in the adult, but is continued as a solid cord to the front wall of the abdomen, on which it ascends, converging towards its fellow, which it meets, a little below the umbilicus. Between it and its fellow are the two internal inguinal pouches of peritoneum which are separated from each other by the urachus medially (fig. 504).

283. THE VESICAL ARTERY arises below the origin of the last, and descends in the peritoneum of the lateral false ligament in which it is crossed by the vas deferens, and is distributed to the parts at the base of the bladder, piercing through the lateral true ligament to its final distribution. A *deferential branch* comes off either from it or from the hypogastric, which ascends on the vas deferens towards the inguinal canal, an *inferior branch* descends through the prostatico-vesical venous plexus to the perineum, where it anastomoses with a branch of the inferior rectal division of the pudic artery. Its *vesical* branches pass to the wall of the bladder, and some small *prostatic* branches to the prostate: a *vesicular* branch supplies the vesiculæ seminales. The vesical artery of the female is large, and gives off vaginal in place of prostatic arteries.

284. THE MIDDLE RECTAL ARTERY often arises with the last, and passes below it to the sides of the middle third of the rectum; here it sends branches upwards to anastomose with those of the inferior mesenteric, and downwards to communicate with those of the pudic.

285. THE UTERINE ARTERY in the female arises close to the last, and passes tortuously between the layers of the broad ligament, to end in the muscular wall of the uterus. It forms on each side a looped arch of communication with the ovarian artery from the aorta.

286. THE OBTURATOR ARTERY arises close to the hypogastric, and passes directly forwards and downwards below the obturator nerve a little below the brim of the pelvis, but between the pelvic fascia and the peritoneum. Before it enters the obturator canal it sends off a *nutrient* branch to the ilium, and an *epigastric* branch which ascends and anastomoses with the epigastric branch of the external iliac.

In four cases out of every eleven this trunk is large, on one side or the other, and the parent obturator trunk from the internal iliac is small or absent. In such cases the functional obturator becomes a branch of the epigastric artery.

The obturator also gives off a *pubic* branch, which passes inwards and communicates with its neighbour and with the pubic branch of the epigastric behind

the symphysis pubis above the anterior true ligaments of the bladder. The *terminal* external and internal branches are described below (§ 357).

The irregular epigastric origin of the obturator is interesting in connection with its relation to femoral hernia. It usually descends close to the external iliac vein, and so lies external to the neck of the sac of a femoral hernia, and is therefore safe from the knife in herniotomy. In rare cases, about once in every fifty-eight bodies, this vessel, however, lies on the inner side of the femoral ring, and so is endangered in dividing the stricture in strangulated femoral hernia. These statistics are taken from 460 bodies. The anomaly is commoner in males than in females, 7 : 3.

287. THE SCIATIC AND PUDIC ARTERIES.—The remaining branches of the internal iliac usually arise by a common trunk and descend within the pelvis on the *pyriformis* and sacral plexus to the lower part of the greater sciatic notch; here they escape together, the pudic lying anterior and internal to the sciatic.

The sciatic artery makes its exit between the branches of the smaller sciatic nerve postero-internally, and the trunk of the great sciatic externally, under cover of the *gluteus maximus*, into which it sends a large inferior gluteal branch. The other branches are described below (§ 326).

The **pudic artery**, smaller than the sciatic, escapes behind it and on a deeper plane, and then turns in through the small sciatic notch, lying on the *obturator internus* muscle and between the pudic nerve on its inner side, and the internal obturator nerve on its outer. It gives off before it leaves the pelvis, branches to the *pyriformis*, *coccygeus*, and *internal obturator* muscles. As it escapes it gives an anastomotic branch to the sciatic and a nutrient to the *gemellus superior*. Its terminal branches in the perineum have been already described (§ 226).

This artery is much smaller in the female, and gives off usually three branches, a larger superior long perineal, a smaller artery of the bulb, and a terminal branch.

288. THE EXTERNAL ILIAC ARTERY is in the adult a larger trunk than the internal (9 : 8), and is the main arterial stem of the lower limb; it is usually about 8·5 mm. in diameter and 10 cm. long, and descends inclining outwards along the brim of the pelvis to escape through the *lacuna vasculosa* of the crural arch, becoming femoral as it crosses the ilio-pubal eminence. It is covered by the peritoneum and a strong layer of sub-peritoneal areolar tissue ("**Abernethy's fascia**"), and is crossed at its origin by the ureter. About the middle of its course in the male it is crossed by the vas deferens, and in the female by the ovarian artery. Close to its termination it is crossed by the deep circumflex iliac vein. It lies on the brim of the pelvis, the *psaos* (which at first lay external to it), the iliac fascia, and its own vein (which becomes internal to it close to Poupart's ligament). The sigmoid colon on the left and the last coil of ileum on the right also usually cross it. The great femoral lymphatics pass along its posterior and outer border, and there are usually four glands overlapping the artery. The genital branch of the genito-crural nerve and the spermatic vessels of the male also cross over the artery near its termination.

Besides the small branches to the lymphatic glands and to the *psaos*, the external iliac gives off two larger branches.

289. THE EPIGASTRIC ARTERY arises from the lowest centimetre of the trunk of the external iliac, and at first passes inwards and then ascends towards the metasternum. In the first part of its course it lies behind Poupart's ligament and the inguinal canal, having the deep abdominal ring to its outer side, and the superficial to its inner; here it lies on the peritoneum and beneath the fascia transversalis, and has the spermatic cord winding round its outer side. As it ascends it pierces the transversalis fascia, enters the sheath of the rectus at or close to the line of Douglas, lying on the back of the *rectus* muscle, and

ascending past the umbilicus to anastomose with the superior epigastric branch of the internal mammary artery.

In its course the epigastric artery is accompanied by two veins, the inner of which is the larger; these unite below as they pass behind the inguinal canal, and the combined trunk ends in the external iliac vein.

The branches of the epigastric artery are (1) a *cremasteric* branch which descends on the spermatic cord to supply the *cremaster* and to anastomose with the inferior pubic branch of the femoral artery and with the long perineal artery. (2) A *pubic* branch, which forms a rete with the pubic branch of the obturator, and joins its fellow above the pubis, behind the rectus and upper border of the bone. (3) An *obturator* branch, to anastomose with a branch of the obturator; this occasionally dilated anastomosis becomes the origin of the irregular obturator artery (p. 426). (4) *Parietal* branches in the abdominal wall. (5) *Anastomotic* branches which are twofold — (1st) superficial, which pierce through the rectus and ventral foramina to join the superficial epigastric of the femoral; and (2nd) terminal, which join the internal mammary.

290. THE DEEP CIRCUMFLEX ILIAC ARTERY arises opposite the epigastric, and just within the crural arch; it ascends often in a fascial canal along the white line of union of the transversalis and iliac fasciæ behind Poupart's ligament to the superior iliac spine, and from that point passes between the *transversalis* and *internal oblique* muscles along the iliac crest, sending upward a large abdominal branch which communicates with the last intercostal and the lumbar arteries, and sending backward branches to join the ilio-lumbar. Some superficial branches join the superficial circumflex iliac artery and the superficial gluteal.

This artery is accompanied by two veins which unite into a single trunk that crosses the external iliac artery. Close to its origin it gives off branches to the *iliacus* muscle.

291. THE SACRAL AORTA is a very small trunk, about 2 mm. in diameter, continuing downwards from the abdominal aorta, below the origin of the common iliacs, and behind the left common iliac vein on the middle of the sacrum, giving off the fifth lumbar artery on each side as well as the first, second, third, and fourth sacral arteries; these pass on each side into the respective sacral foramina, and are distributed to the walls of the sacral canal and to the parts on the back of the sacrum. At the sacro-coccygeal joint the artery becomes **middle coccygeal** or caudal, and is continued downwards to the tip of the coccyx, where its terminal branch passes outwards to end in the coccygeal glomerulus (p. 354). Small varicosities project on each side of the coccygeal artery and its branches. A few inconstant visceral branches pass forwards from the sacral and coccygeal aortæ to the hinder wall of the rectum.

292. THE TRIBUTARIES OF THE INFERIOR VENA CAVA.—The dorsal vein of the penis (p. 370) having pierced the sub-pubic fascia, divides into a plexiform cluster of branches, which become parted at the base of the bladder into two series, one on either side, receiving branches from the prostate, the seminal vesicles and bladder. This **prostatico-vesical plexus** is of considerable capacity, and ends in a stem which passes backwards and upwards towards the inner side of the internal iliac artery. In its course it receives the sacral veins emerging through the sacral foramina, and forming a close-meshed plexus on the front of the sacrum, and it also receives the large and netted system of rectal and anal (proctodæal) veins which ascend on the outside of the muscular coat of the rectum (the only intestinal veins which do not join the vena portæ). The pudic vein returning the blood from the corpora cavernosa and superficial parts of the perineum, joins it close to the sciatic notch, and still higher the two sciatic veins unite and join the trunk, which is from this point

called the internal iliac vein. Into this vessel on a higher level the two gluteal veins, the ilio-lumbar and the superior lateral sacral veins, empty themselves as well as the obturator.

All these branches are well furnished with valves, but there are none in the trunk.

The **external iliac vein** is the continuation of the femoral (§ 345), and lies at first internal to its artery on the superior ramus of the pubis, afterwards becoming posterior to it, and joining the internal iliac vein behind the internal iliac artery. It receives the epigastric and circumflex iliac veins as well as a large ascending branch of the obturator vein.

There are usually two pairs of valves in this vein, one functional, the other rudimental.

The **common iliac veins** ascend converging on the front of the vertebral column, the right lying behind and external to its artery, the left crossing the promontory of the sacrum and the fifth lumbar vertebra. They unite on the fifth lumbar vertebra to form the **inferior vena cava**. The right is shorter and more vertical, the left longer and more oblique.

There is usually an incompetent valve in the latter, none in the former. Into the left common iliac vein the two middle sacral veins open, which ascend from the upper part of the presacral venous plexus.

293. THE INFERIOR VENA CAVA is a large trunk 35 mm. in diameter above when fully injected, but rarely cylindrical in shape during life, as it is influenced by the pressure of surrounding parts. It ascends from the level of the fifth lumbar vertebra, passing through the caval opening in the diaphragm opposite the level of the lower border of the ninth dorsal vertebra. As it ascends it passes a little forwards and to the right, lying at first behind the aorta, but terminating on a plane in front of it and separated from it by the right crus of the diaphragm, and the Spigelian lobe of the liver.

It is under cover of the peritoneum, especially the root of the mesentery, the right spermatic artery, aortic plexus, ascending colon, duodenum, head of the pancreas, the portal vein, and the hinder surface of the liver. It is separated by a single layer of peritoneum from the posterior wall of the foramen of Winslow, and lies in a deep groove on the hinder surface of the liver, bridged by a thin membranous band of hepatic substance, the **ponticulus hepatis**. It lies on the vertebral column, the right crus of the diaphragm, the right renal artery, the right semilunar ganglia, and the right lumbar arteries.

As it ascends it (1) receives the four upper **lumbar veins** on each side, those of the right passing behind the aorta. These veins arise by branches corresponding to the branches of the lumbar arteries. As the left lumbar veins pass inwards they are joined together by an ascending anastomotic branch which connects them together, and which above passes through the diaphragm as the ascending lumbar vein to form the root of the vena hemi-azygos (the remnant of this portion of the left cardinal vein).

(2) The veins forming the **spermatic (or pampiniform) plexus** of the right side, ascending from the spermatic cord, unite into one trunk which ends in the inferior vena cava opposite the third lumbar vertebra, those of the left join the left renal.

Several small imperfect valves are found in the spermatic plexus, one, which is competent, usually guards the upper or terminal orifice.

(3) The **renal veins** are large short trunks which enter the vena cava as it passes the kidneys, joining it at right angles. The left renal vein passes usually in front of the aorta below the superior mesenteric artery and behind the duodenum; it is longer and a little higher up than the right, and receives the spermatic vein. Each renal vein receives a suprarenal branch, which has a valve at its mouth, and an imperfect, never competent valve is usually present in the left renal, a still more imperfect rudiment in the right.

The right **middle suprarenal vein**, which is very large in comparison with the artery that it accompanies, joins the vena cava above the renal. The left middle suprarenal joins the renal.

Behind the liver the vena cava receives its largest tributaries, the **venæ cavæ hepaticæ** described in connection with the liver, after which it passes through the tendinous caval opening in the diaphragm to enter the pericardium. As it ascends it receives on each side two phrenic branches from the diaphragm.

The inferior vena cava, as far as the inferior surface of the liver, is a dilated portion of the right cardinal vein. The portion behind the liver is a dilated communication between the cardinal vein and the sinus venosus, and the portion below the liver is the lower part of the sinus venosus. There is usually a small vessel which connects the infrahepatic part of the vena cava with the lowest part of the vena azygos, completing the continuity of the cardinal vein. The right common and internal iliac veins and the inferior lateral sacral veins are the lowest parts of the cardinal vein. The left common iliac is a dilated secondary communication comparable with the left innominate vein (see p. 87).

294. VENA PORTÆ.—The veins carrying back the blood from the digestive canal end in a short trunk, the vena portæ which, entering the liver, breaks up therein into capillaries from which the blood is ultimately returned into the vena cava.

The three trunks, which by their confluence form the vena portæ, are the splenic, the inferior mesenteric, and the superior mesenteric veins.

The **splenic vein** is formed by the union of 5 or 6 efferent veins in the hilum of the spleen, and passes rightwards grooving the upper and back part

of the pancreas, below the tortuous splenic artery. It receives in its course three *venæ breves* from the stomach, the left gastro-epiploic vein and the greater, and several left lesser pancreatic veins. To the left of the aorta it joins with the inferior mesenteric vein nearly at right angles, and the combined trunk, about 1 cm. long, crossing the aorta joins the superior mesenteric in the angle formed by the inferior lobe of the head of the pancreas, in front and to the left of the vena cava inferior.

The **inferior mesenteric vein** begins by the union of the upper ascending branches of the rectal plexus of veins in the mesorectum; it ascends to the left of its artery and to the left of the aorta, receiving veins from the sigmoid flexure and descending colon.

Leaving the artery close to its origin it ascends behind the peritoneum and behind the inferior part of the duodenum and pancreas to join the splenic vein.

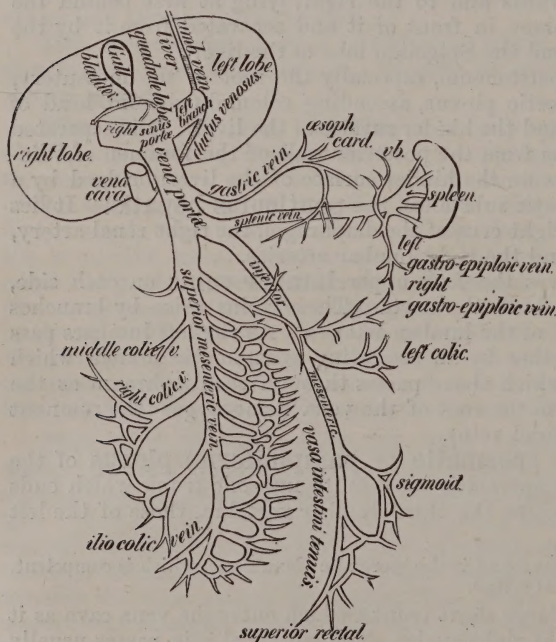


Fig. 554.—Scheme of the system of the vena portæ.

The **superior mesenteric vein** is formed by the junction of the veins corresponding to the branches of the superior mesenteric artery; these, like the other veins of the portal system, are single concomitants of each artery, and the main trunk lies in front and to the right of that vessel. It passes in front of the duodenum and in the angle of the pancreas (§ 265). It receives the veins of the small intestines, ileo-colic, right and transverse colic veins, and, close to its termination, the right gastro-epiploic and inferior pancreatic veins.

The **vena portæ** is formed on the right of the body of the second lumbar vertebra, and ascends a little to the right, at first behind the head of the pancreas and the first part of the duodenum, then in the layers of the lesser omentum behind and between the hepatic artery (to its left) and duct (to its right). It enters the transverse fissure of the liver near its right end, and there, appearing to dilate, it divides into a short, large right and a longer, narrower left branch, which diverge from each other at an angle of 160° . The right supplies the right and quadrate lobes, the left after a short course joins, where it crosses the longitudinal fissure, the obliterated umbilical vein in front, and the obliterated ductus venosus behind. From the left arise the branches to the Spigelian, left and quadrate lobes (p. 410).

The vena portæ receives (1) the left pancreatic veins; (2) the pancreaticoduodenal vein; (3) the pyloric from the omental edge of the antrum pylori; and (4) the gastric vein, which, having accompanied the gastric artery, turns to the right behind the posterior wall of the omental cavity and ends in the vena portæ. Its right branch receives the cystic vein.

The veins from the hepatic capsule and parenchyma communicate with the interlobular branches of the vena portæ as internal roots of the vena portæ. Some minute anastomotic branches from the left branch of the vena portæ anastomose with the parietal, and especially the epigastric and phrenic veins in the falciform ligament, the lowest of these is called the *par-umbilical vein*, and may represent the anterior abdominal vein or the primitive suprahepatic termination of the hypoblastic vein (p. 86).

The radicles of the inferior œsophageal, pancreatic, and especially the superior rectal veins communicate with the veins of the caval system, the duodenal and colic are said to do so also, but this I cannot verify. There are valves guarding the mouths of each branch of each gastric vein, and of the omental veins in children, but none in any of the larger trunks throughout the whole portal system.

295. ABDOMINAL LYMPHATICS.—The pelvic lymphatics are very abundant and large; they accompany the branches of the internal iliac vein. The obturator lymph-vessels entering through that foramen end in a small gland below the obturator blood-vessels. The pudic lymphatics communicate with two or three glands in common with the sciatic lymphatics. The pudic series drain the perineum, but not the penis or scrotum. There is generally a fairly large-sized single gland on the gluteal lymphatics above the pyriformis muscle. The efferent lymphatics of these glands join with those coming from the bladder which are very numerous and which stream in two sets, anterior and posterior. The anterior join the prostatic lymphatics, and pass backwards above the prostatic-vesical veins in the lateral true ligament where there is a gland; the posterior join the rectal, or in the female the very abundant uterine and vaginal lymphatics, and all unite in the hypogastric lymphatic plexus on each side upon the internal iliac vein wherein are four or five glands. The efferent lymphatics of these join the external iliac lymphatics, which, with their three glands, lie along the back and outside of the external iliac artery, receiving the femoral and inguinal branches, as well as those of the abdominal wall which accompany the deep epigastric and circumflex iliac arteries; on the last-named set there is usually a gland close to the anterior superior spine.

The common iliac lymphatics are five or six large trunks which, by their

branchings, surround the common iliac vessels and pass through two or three glands. Those on the left side receive numerous branches from the sacral lymphatic plexus, and on either side they end by joining the inferior lumbar vessels.

The sacral plexus of lymphatics consists of a fine network of lymph vessels, in connection with which there is a small gland at each sacral foramen, and three larger ones in the layers of the mesorectum close to the promontory of the sacrum; these vessels drain the back of the rectum, the spinal canal, and other parts about the sacrum, and end above by communicating on the right with the inferior lumbar lymphatic trunks, on the left with the common iliac lymphatics.

The lumbar lymphatic plexus is very large and loose-meshed lying behind the peritoneum at each side of the aorta, and in front of the psoas muscle. They are united across the aorta by a median aortic lymphatic plexus, with about six glands in its course. They begin below by receiving the lymph vessels of the common iliac and sacral plexuses, and where these join there are usually four or five glands. The efferent lymphatics of these on the left side receive the trunks from the wall of the descending and sigmoid colon in connection with which there are twenty mesocolic glands; on both sides they receive the spermatic lymphatics from the testis and its deep coverings, which usually do not enter a gland until they reach this plexus. In the female the ovarian and tubal lymphatics pass up in similar manner from the broad ligament. The abundant kidney lymphatics and those of the suprarenal capsule form a close plexus around the renal vessels, communicating with a small cluster of glands above the renal artery. A set of lymph channels likewise enter the plexus between the *psoas* and the vertebral column around each lumbar artery, and form a chain of glands

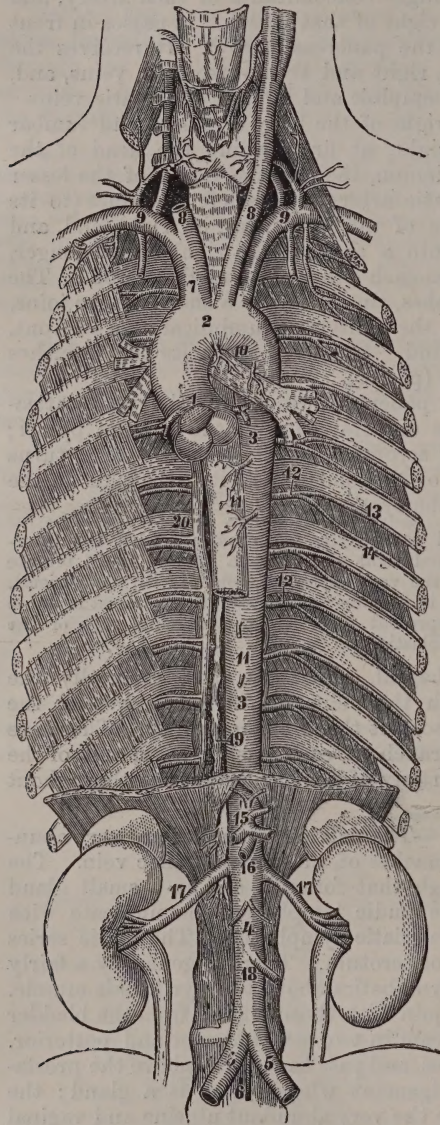


Fig. 555. — Thoracic duct and receptaculum chyli. 19, Thoracic duct, for other references see § 212.

along the inner edge of the *psoas*. These all unite, and at the upper part of this plexus the trunks become fewer and larger, until finally they unite on each side of the second lumbar vertebra into a right and left **truncus lymphaticus lumbalis**. The left crosses behind the aorta, so both lie

between the aorta and the vena cava, and usually cross each other once or twice before they unite, which they do behind the right renal artery. There are altogether about twenty glands in the lumbar plexus of lymphatics on each side.

The lymph channels arising from the intestines are called **lacteals**, and are extremely numerous, large, and plexiform, leaving the small intestine on both sides of the arteries. They lie between the layers of the mesentery as far as the last set of arching branches of the artery; here they form a primary set of small and not very numerous glands, about 4 cm. from the intestine. The large efferent vessels from these pass without very many communications to a much larger number of larger secondary glands on the primary set of arches of the arteries, and from these the efferent trunks become closer and larger, and form a very large tertiary set of glands along the trunk of the superior mesenteric artery. Those from the jejunum are much more numerous than those from the ileum, and sometimes run together into a compound mass of glands on the left of the superior mesenteric vein below the pancreas, but they are seldom confluent enough to form a mass like the so-called *pancreas of Aselli* in lower animals. There are altogether about 220 glands in the whole extent of the mesentery. The lymph channels between these glands are wide and liberally furnished with valves.

The lymphatics of the cæcum and ascending colon are fewer, but arranged in the same way, traversing about fifteen mesocolic glands on the right side on their way upwards. Those of the transverse and upper half of the descending colon converge in like manner along the trunk of the colica media artery in the transverse mesocolon, traversing about twenty-five glands, and these unite with the efferent ducts of the tertiary series of mesenteric glands, and pass to the right of the superior mesenteric artery on a plane behind the superior mesenteric vein.

Converging to these vessels are the efferent vessels of the usually twenty large celiac glands, which lie behind and above the pancreas, and in front of the aorta, above the right of the origin of the superior mesenteric artery. Into the leftmost pair of these pass the lymphatics of the spleen which are neither numerous nor large, and differ from the others in usually containing a reddish fluid. There are about eight pancreatico-splenic glands in connection with these, which also receive most of the pancreatic lymph, and some from the left end of the stomach, and whose efferent vessels accompany the splenic vein.

The lymphatics of the stomach are also extraordinarily numerous, and leave the organ in three sets—one set, just referred to, join those of the spleen; one large series of superior gastric lymphatics accompany the gastric artery, and passing through five small superior gastric glands, enter the uppermost of the left set of celiac glands; a third, the largest set, accompany the gastro-epiploica dextra to the rightmost of the celiac glands, joining with the lymphatics of the upper part of the duodenum. There are usually six gastro-epiploic glands in this plexus, which also receive the lymphatics of the great omentum.

The most of the hepatic lymphatics (p. 415) leave the liver at the transverse fissure, descending in front of the vena portæ in the lesser omentum, and joining the uppermost of the right celiac glands, which also receives the lymphatics of the gall-bladder and duct. A few of the superficial hepatic lymphatics pass through the coronary and left lateral ligaments to the diaphragm, and some, through the falciform ligament, communicate with the anterior mediastinal system.

The celiac glands communicate together, and with the tertiary mesenteric glands, by many branches, and their very short efferent trunks unite into three or four stems, which join the terminal efferent stems of the mesenteric glands to form a common trunk, the **truncus lymphaticus intestinalis**. This short

stem passes backwards on the right of the superior mesenteric artery, and by its union with the stem formed by the two united lumbar lymphatic trunks forms the **receptaculum chyli** on the level of the second lumbar vertebra.

This thin-walled sac lies on a plane behind and between the aorta and the tendinous edge of the right crus of the diaphragm, behind the right renal artery, and is somewhat fusiform, about 35 mm. long by 7 mm. broad. Its continuation, the **thoracic duct** ascends through the aortic opening in the diaphragm into the thorax (§ 216) and empties all the lymph and chyle from the abdominal cavity. There are very few valves in the short converging main stems and none in the receptaculum. The receptaculum receives the posterior hepatic and the right pancreatico-gastric lymphatics directly.

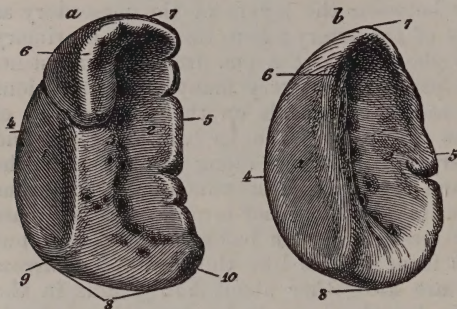


Fig. 556.—Spleen, $\frac{1}{2}$ —*a*, concave or right surface; *b*, convex or left surface; 1, posterior border; 2, anterior part of the right surface; 3, kidney impression; 4, convex surface; 5, notched anterior margin; 6, diaphragmatic surface; 7, upper end; 8, lower end.

the left hypochondrium. It presents an outer convex diaphragmatic surface directed upwards and backwards, and an inner concave surface divided into two by an irregular line, the hilum, along which the vessels enter and leave the organ, and whose lower border lies on the tail of the pancreas. Behind the hilum is a smooth concave depressed area moulded on the upper and outer border of the left kidney which is below it, separated from the diaphragmatic surface by the obtuse margin. In front of the hilum is a broader concave surface which lies in contact with the bulging end of the stomach in front and to its right side. This gastric area joins the diaphragmatic in the

296. THE SPLEEN is an organ closely connected with the lymphatic system, which can best be examined in this connection. It is an oval body about 12.5 cm. long, by 7 broad and 4 thick, and lies in the anterior or crenated margin, which lies beneath the cartilages of the ninth to the eleventh ribs. The notches in this border are sometimes palpable through the abdominal wall in enlarged spleens. The upper end is broader and thicker and directed forwards, the lower is narrower, thinner, and directed backwards. Below it is the splenic flexure of the colon. A line drawn from the left sterno-clavicular joint to

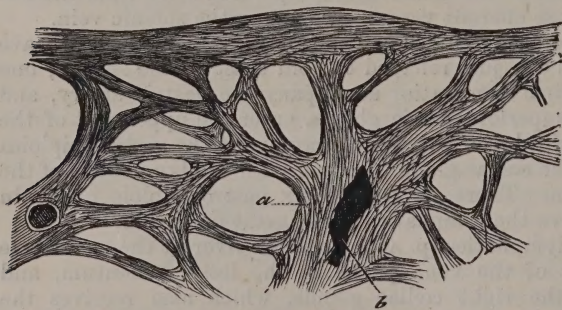


Fig. 557.—Portion of capsule and trabeculae of spleen—*a*, trabecula; *b*, vein.

the tip of the eleventh rib on the left, bounds the edge of the spleen.

The spleen is well covered by peritoneum, except along the hilum, the upper end of which is connected to the diaphragm by a fold of peritoneum above, the **phreno-splenic ligament** (fig. 515, *ls*). The hilum is connected by two layers, continuous up from the left pancreatico-duodenal fold to the

diaphragm behind, the **posterior splenic ligament**, and by two layers to the great bulging end of the stomach, the **gastro-splenic omentum**, the front layer of the former and the hinder of the latter being the left layers of the omental bag, while the two other layers are those which are continued downwards from the phreno-splenic ligament (§ 251; fig. 512).

The spleen is deep purplish in colour and brittle in texture. Under the peritoneum and almost inseparable from it is a capsule of tough but thin areolar tissue which sends in trabeculae, coarse and fine, branching in all directions through the substance of the organ, making a spongy skeleton for it, whose finest subdivisions are of microscopic size, and whose meshes are filled by the **spleen pulp**. These trabeculae can be demonstrated by washing out the spleen pulp with a stream of water; they contain smooth muscle cells, which are sparingly distributed in the substance of the capsule. Within the meshes of the trabeculae is a finer network of adenoid tissue making the ground substance of the spleen pulp. Into this capsule the arteries pass, dividing repeatedly, and ending in pencil-like sets of diverging branches. These finest branches have lost their outer sheaths from the trabeculae, and so they lie within the masses of spleen pulp. These terminal pencils of branches do not anastomose with each other. The sheaths of the capsule surround and unite with the adventitia of the coats of the arteries before their ultimate division, and these exhibit nodular thickenings of reticular tissue, containing lymph cells, which are called **Malpighian corpuscles**, greyish specks, 1 mm. in diameter, and of these there are about 5000 in the human spleen. The arteries end in capillaries, whose walls instead of being perfect are reticular, allowing the blood to escape into the intermediate intercellular spaces among the mesh-work of the fine spongy skeleton. From these cavernous lacunar spaces veins arise, the venous

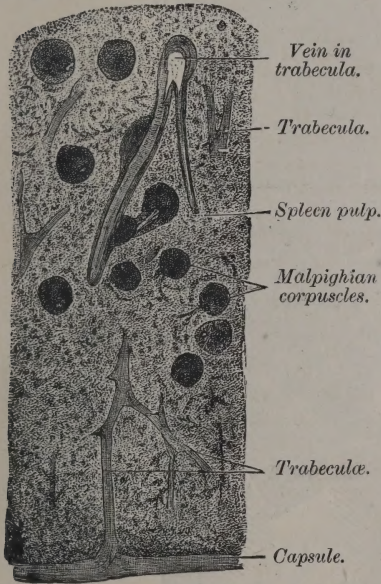


Fig. 558.—Section of spleen. $\times 10$.

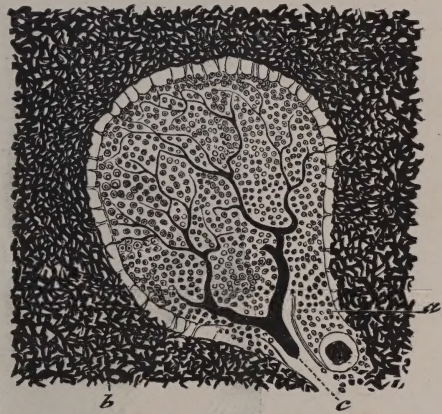


Fig. 559.—Malpighian corpuscle—*a*, artery; *b*, spleen pulp; *c*, artery of the capsule. $\times 50$.

radicles being wide and anastomosing, and uniting to form the efferent veins which escape at the hilum. The venous radicles are lined by spindle-shaped endothelial cells. They anastomose frequently, and enter the substance of the trabeculae through which they pass, uniting with their fellows towards the hilum.

The spleen thus resembles a lymphatic gland in which blood from the reticular vessels had invaded the lymph paths, hence it is that the lymph corpuscles of these follicles gain admittance directly into the vessels. There are two sets of splenic lymphatics—a superficial, which forms a plexus under the peritoneum, and a deep, which consists of fine perivascular spaces in the adenoid tissue around the vessels, and of the channels which carry the lymph therefrom.

The nerves from the splenic plexus are principally distributed to the vessels.

The material in the pulp contains several kinds of blood corpuscles; in various stages of formation and disintegration.

297. THE KIDNEYS, seen when the colon is removed, are two nearly symmetrical organs on the back wall of the abdomen, one in each lumbar region. The right is a little lower than the left, being depressed by the liver, and lies at the side of the last dorsal and the first, second, and upper edge of the third lumbar vertebræ, while the left is usually related to the lower edge of the

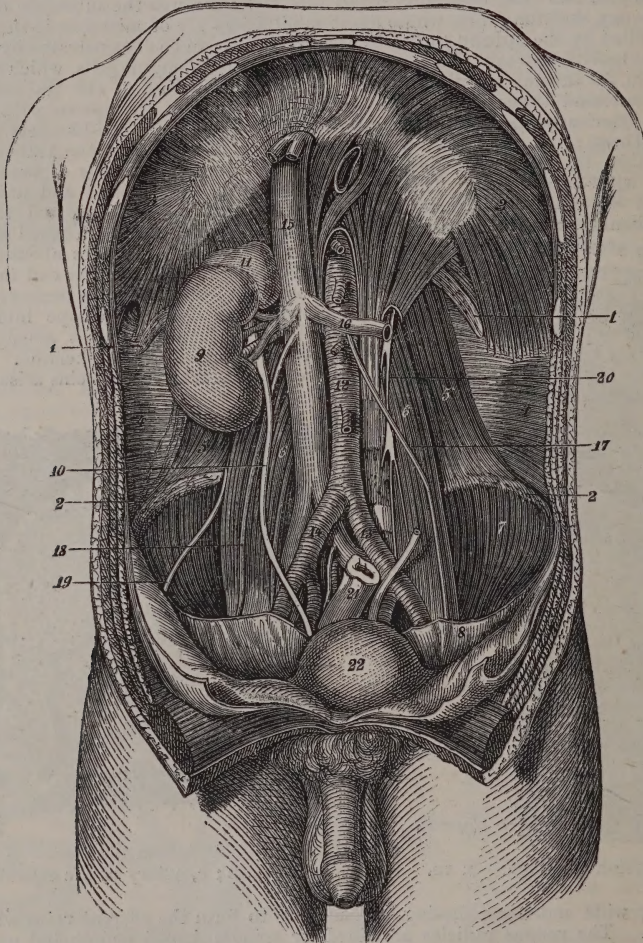


Fig. 560.—Abdomen opened, showing the position of the right kidney (9). The left has been removed—10, ureter; 11, suprarenal body; 16, left renal vein; 17, 18, spermatic veins.

eleventh dorsal as well as to the twelfth, and to the first and second lumbar vertebræ. The twelfth rib crosses the back of each kidney, dividing it into two unequal halves, and the convex outer edge of each organ is on a level 10 cm. external to the spine of the first lumbar vertebræ.

The posterior surface of each kidney is flattened, and rests on a loose connective mass, the **tunica adiposa**, which separates its upper third from the *diaphragm*, its lower two-thirds from the fascia covering the *quadratus*

lumborum muscle and from the ilio-hypogastric nerve, and its inner border from the edge of the *psoas*. Below each kidney is a similar fatty and areolar mass, separating it from the iliac crest, which is 3 to 5 cm. below it. In front of the right kidney lie the ascending colon, the second part of the duodenum, and the peritoneum for a small area to its outer side, while above it is the right lobe of the liver and the suprarenal capsule (§ 314). In front of the left kidney is the tail of the pancreas, the stomach, the descending colon, the peritoneum joining the mesentery to the left lumbar mesocolon, and the spleen, which last, with the diaphragm and the left suprarenal capsule, also lie above and external to it.

The peritoneal investment of the right kidney is confined to about four-fifths of its anterior surface, of the left to two-thirds. It is easily stripped off, and should be removed without injury to the suprarenal capsules and the vessels. When thus cleaned the kidney presents a convex anterior surface and a convex outer margin directed a little backwards, an upper extremity slightly the larger, directed forwards and inwards, a lower extremity, smaller and flatter, directed backwards and a little outwards. The axes of the two kidneys, if prolonged, will meet at an angle of 60° on the ninth dorsal vertebra.

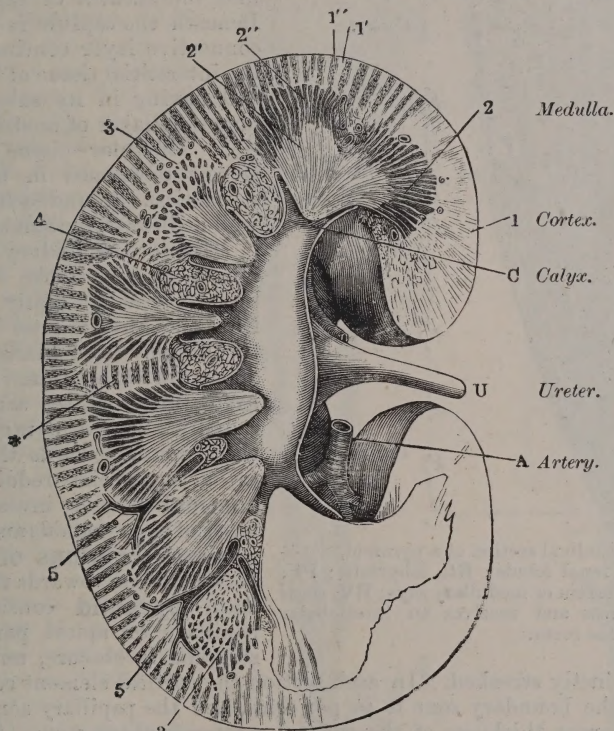


Fig. 561.—Longitudinal section of kidney, $\frac{1}{2}$ —1', medullary rays; 1'', labyrinth; 2', papillary portion of medulla; 2'', boundary layer of medulla; 3, transverse section of tubules in boundary layer of medulla; 4, interpyramidal fat; 5, artery; *, medullary rays.

[] In comparing the two kidneys the right appears a little shorter and broader, the left is slightly the larger.

The inner anterior margin is concave and presents a longitudinal fissure, the **hilum**, whereinto the vessels pass. The foremost of these is the renal vein, usually the highest on the right side. Intermediately are the branches of the

renal artery, some of which lie above the vein on the left side. Behind and below is the ureter, which therefore constitutes the easiest guide to distinguish the side to which a kidney, removed from the body, has belonged.

The hilum, when its lips are opened, appears as the mouth of a deep indentation, the **sinus** of the kidney. In this sinus the ureter dilates behind the vessels into a large sac, the **pelvis** of the kidney.

Divide the vessels holding one kidney in place, and remove the organ, leaving the suprarenal capsule in place. The detached kidney appears smooth, is 11 cm. long, 5 cm. broad, and 25 mm. thick. The gland weighs 140 grammes in the male, 120 in the female, and its volume is 150 c.cm., its specific gravity 1.05.

The kidney is invested by a strong capsule consisting of areolar tissue containing many elastic fibres, the **tunica albuginea**, which is easily peeled off without injuring the subjacent gland-tissue, except at some minute spots and at the hilum, where it turns inward and is continuous into the sheaths of the vessels. Beneath the capsule is a deeper connective layer continuous into the interstitial tissue of the organ and having in its substance an imperfect layer of unstriated muscle. Muscular tissue is most largely developed in the interstitial tissue around each papilla as well as in interpyramidal bands.

Divide the kidney longitudinally by one stroke of a large knife carried steadily through from the convex outer border to the hilum. Two kinds of tissue appear in the section, (1) a paler **medullary** matter arranged in radially striated pyramids with their apices towards the hilum; (2) a superficial reddish-brown **cortical** matter investing the bases of the pyramids and sending processes (**columns of Bertin**) between them towards the hilum. Each **pyramid** consists of a papillary or apical part, whose striation is obscure, and a bound-

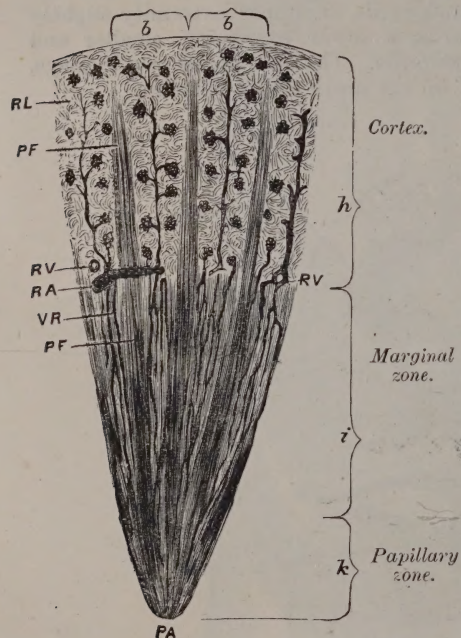


Fig. 562.—Longitudinal section of a pyramid, $\times 5$ —
b, base of a renal lobule; RL, labyrinth; PF, pyramid of Ferrein or medullary rays; RV, renal vein cut across and receives an interlobular vein; VR, vasa recta.

dary zone distinctly streaked. In each section the cortical element constitutes 35 per cent., the boundary zone is 40 per cent., and the papillary zone 25 per cent. The average thickness of the cortical matter is about 1 cm. There are about fourteen pyramids in the kidney, of which about eight are cut through in this vertical section. Each of these was a primitive lobule in the embryonic kidney. The pyramids end in **papillæ**, of which there are usually about ten, each of which projects into a short membranous tube or **calyx**. The 8-10 calyces speedily unite into **infundibula**, of which there are two or three, and these by their confluence form the **pelvis**.

The surface of each papilla within the calyx is covered by mucous membrane, often depressed into pits, and each is perforated by 40-60 minute holes, each

about .08 mm. in diameter, the openings of the excretory tubules whereof the pyramids consist. When the kidney is squeezed a drop of urine exudes from each papilla.

From the base of each pyramid radial streaks (**medullary rays**) pass outwards into the cortical matter, and the areas between these, which are red and granular, are called the **labyrinths** of the kidney.

The kidney is made up of tubules, blood-vessels, and a scanty interstitial connective tissue which, however, may become very much increased in amount in disease. The tubules, which consist of a homogeneous basement and an epithelial layer, begin in the labyrinth as (1) oval sacs (fig. 563, i), the **capsules of Bowman**, each of these is about $220\ \mu$ in diameter and is lined by a thin layer of flattened epithelium (fig. 564, k). Each capsule has (2) a narrow **neck**, which joins (3) a wide tortuous tube (fig. 563, x) (**the primary convoluted tube**), lined by short irregular cells, each of which consists of two parts, an inner of cloudy protoplasm, with a circular nucleus directed towards the lumen, and an outer fibrillated part attached to the basement layer, with brush-like processes which are joined to those of neighbouring cells by interlacing with them (fig. 564, III.) No capsules exist in the superficial layer of the cortex nor in the layer immediately in contact with the boundary zone.

(4) These tubes pass to the nearest medullary ray, where they become regularly spiral (**the spiral tube**), and descend in the ray towards the boundary zone of the pyramid. The epithelium of the spiral tubes is of the same kind, but flatter.

(5) At the base of the pyramid the spiral tube suddenly narrows and

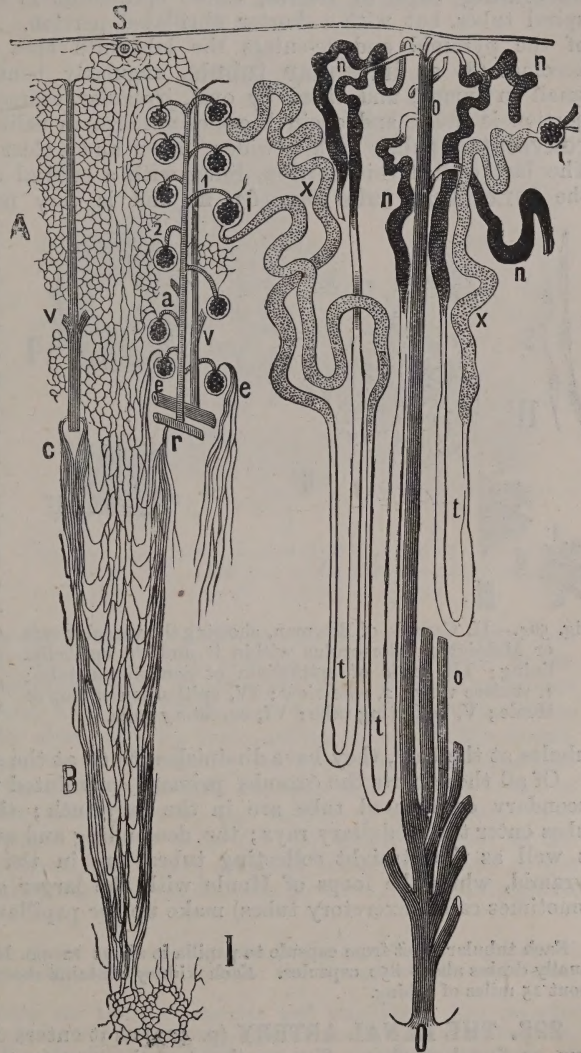


Fig. 563.—Diagrammatic view of the tubules (right side of figure) and vessels (left side) of kidney—A, capillaries of cortex; B, capillaries of medulla; S, one of the stellate veins (venæ stellatæ of Verheyen) cut across.

descends vertically into the pyramid as far as the papillary area; this portion is the **descending tube of Henle** (fig. 563, t) and has a lining of clear flat cells with bulging nuclei which alternate on opposite sides of the tube, giving to the lumen in longitudinal optical section a sinuous appearance (fig. 564, IV.) When these tubes reach their lowest point they suddenly turn backwards, making (6) the **loop of Henle**, and from this there ascends (7) a wider **ascending tube of Henle**, whose epithelium is somewhat like that of the spiral tubes, but with a shorter fibrillated portion. This emerges at the base of the pyramid and re-enters the labyrinth area of the cortex, where it becomes (8) an **irregular tubule**, angularly bent, irregular in diameter, small in lumen, and lined by oval, irregular, coarsely fibrillated cells. This portion is short, and again becomes uniform in calibre as (9) the **secondary convoluted tube**, with a wider lumen and a clear lining of flattened cells. The last coil of this portion, lined with a cubical epithelium, is called (10) the **junctional tube** (fig. 563, n), and is very narrow, and ends, in the

medullary ray, by joining (11) a straight **collecting tube** (*ib.*, o). These are lined by columnar epithelium, and descend directly into and through the pyramid. Each of these "straight tubes of Bellini" receives in its course through the medullary ray many junctional tubes, and each unites with its neighbouring straight collecting tubes as it approaches the apex of the papilla, so that from a diameter of $45\ \mu$ at the base they enlarge to $250\ \mu$ at the papilla, while from about 1,400

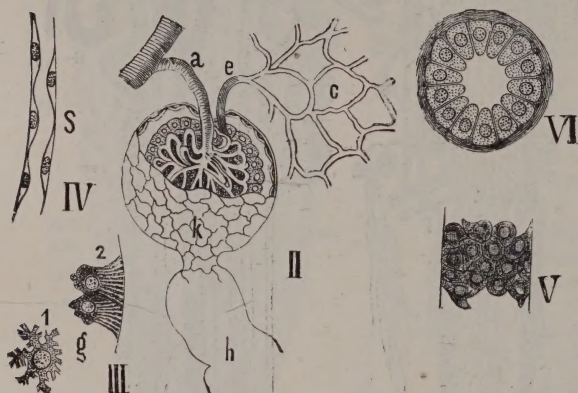


Fig. 564.—II, Capsule of Bowman, showing the vascular tuft or Malpighian glomerulus within it and its epithelial lining; III, cells of epithelium of convoluted tube; I, surface view; 2, side view; IV, epithelium of loop of Henle; V, collecting tube; VI, excretory tube.

tubules at the base, they have diminished to $60\ \mu$ at the apex (fig. 563, o).

Of all these parts the capsule, primary convoluted tube, irregular tube, and secondary convoluted tube are in the labyrinth; the spiral and junctional tubes enter the medullary rays; the descending and ascending tubes of Henle, as well as the straight collecting tubes, are in the boundary zones of the pyramid, while the loops of Henle with the larger collecting tubes (*ib.*, o—sometimes called excretory tubes) make up the papillary zone.

Each tubular tract from capsule to papilla is about 12 cm. long, and each excretory tube usually drains about 850 capsules. Each kidney contains about half a million capsules and about 15 miles of tubing.

298. THE RENAL ARTERY (p. 423) as it enters the hilum breaks up into four or five branches. Two or three of these go to that part in front of the plane of the hilum, and the rest to that behind, and these two sets of vessels communicate but sparingly, although each communicates by arched anastomoses with its neighbour between the pyramids. They send a few branches to the tunica adiposa, which freely anastomose by minute branches through the surrounding fat with the branches of the lumbar and phrenic arteries. The main branches pass in the columns of Bertin between the

pyramids as interpyramidal branches, each of which, on reaching the cortex, gives off straight interlobular branches (fig. 563, a) in the labyrinth passing peripherally. Each of these gives off (*a.*) **vasa afferentia** to the capsules (*ib.*, 1), (*b.*) terminal branches to the surface layer of parenchyma under the deep layer of the tunic, (*c.*) **recurrent straight branches** which run backwards in the pyramids between the tubules (**vasa recta vera**—*ib.*, r), (*d.*) a few very fine vessels distributed to the connective tissues of the cortical matter in which they make a fine-meshed capillary network.

The largest and most important of these vessels are the **vasa afferentia** (fig. 564, a). One of these passes to each capsule, the wall of which it pushes before it at one spot, and projecting into the cavity of the capsule, though enclosed in the very attenuated invaginated sac of the wall thus produced, it breaks up into a little tuft of about twenty looped capillary vessels, the **Malpighian glomerulus**.

These capillaries reunite, forming a vein, the **vas efferens**, smaller than the artery (figs. 563, 2; 564, II, e), and this escapes from the narrow opening of the pouch of invagination close to the

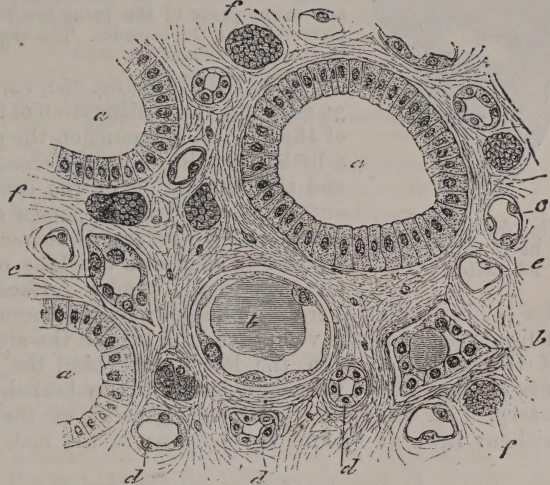


Fig. 565.—Transverse section near the apex of a medullary pyramid—*a*, collecting tube; *b*, *c*, *d*, sections of parts of the loop of Henle; *e*, *f*, blood-vessels.

artery, but has no sooner escaped than it breaks up around the primary convoluted tubes into a fine capillary plexus (fig. 564, II, c) closely applied to the thin basement of the convoluted tubes. From these veins by their re-unions interlobular veins arise, which unite and pass back between the pyramids as interpyramidal veins, which ultimately by their unions make up the renals. The lowest vasa efferentia, nearest to the bases of the pyramids, send pencil-like straight **vasa recta spuria** (*ib.*, e) backwards between the straight tubes of the pyramids. The arteries which pass to the surface of the kidney communicate with clusters of small stellate veins (*ib.*, S) which also end in the interlobular veins. The afferent vessels give off small branches directly to the capillary network of the cortex whose blood does not go through the Malpighian glomerulus.

The watery and saline parts of the urine are excreted in the capsules by a process of transudation depending largely on the difference between the intraglomerular and intracapsular pressure.

The lymphatics of the kidney are twofold, capsular and glandular. The capsular lymphatics form a wide-meshed plexus with large lymph-spaces beneath the tunica albuginea, and converge to the hilum. The glandular lymphatics are very abundant, and begin as wall-less slit-like spaces in the labyrinth around the vessels; from these arise thin-walled lymphatics with scarcely any valves, which surround the larger vessels and meet the superficial lymphatics in the hilum; here they communicate with a cluster of glands around and above the renal artery, and end in the truncus lymphaticus lumbalis (p. 432).

The renal nerves from the aortico-renal plexus (§ 314) accompany the renal artery into the gland. They are very few in number and small in size, and apparently are distributed only on the coats of the vessels. Between the arteries and veins in the hilum are lymphatic glands and minute encapsulated **reniculi**, the remains of modified nephric tubes.

The membranous receivers of the urine begin as wide irregular bags called **calyces**, embracing the papillæ, continuous at the commencement of the calyces with the imperfect smooth muscle layer of the capsule. These, by their unions, form infundibula, which unite to form the **pelvis** of the kidney. These membranous tubes have moderately thick walls which consist of (1) an outer areolar coat, (2) a circular layer of smooth muscle fibres, (3) a layer of radial fibres, (4) a connective tissue submucous layer, (5) a mucous layer in which are embedded a few simple acinous glands and lymphoid nodules but no papillæ, (6) a layer of transitional epithelium (p. 25).

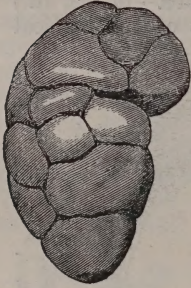


Fig. 566.—Fœtal kidney, showing its lobulation.

The fœtal kidney is lobulated (fig. 566), the lobules representing the several pyramids, each with its cortical mass; but as age advances the growth of the cortical mass obliterates the lobulation. The water and saline parts of the urine are formed by transudation from the glomeruli into the capsules. The organic constituents are secreted by the tortuous tubes.

299. URETER (fig. 560, 10), a pale, collapsed tube, about 35 cm. long, the continuation of the tapering end of the pelvis of the kidney, descends on the psoas muscle, curving at first a little inwards, obliquely crossing the genito-crural nerve and the bifurcation of the common iliac artery. Having entered the pelvis, it passes downwards and inwards in the attached border of the posterior false ligament of the bladder to open into the base of that organ. It is closely attached to the hinder surface of the peritoneum and in the lumbar region is crossed obliquely by the spermatic vessels. On the right it lies external to the vena cava, and behind the attachment of the lowest part of the mesentery; on the left it is behind the sigmoid mesocolon and the inferior mesenteric vein, and is crossed by branches of the inferior mesenteric artery. In the posterior false ligament of the bladder it is crossed from without inwards by the vas deferens in the male, and the obliterated hypo-

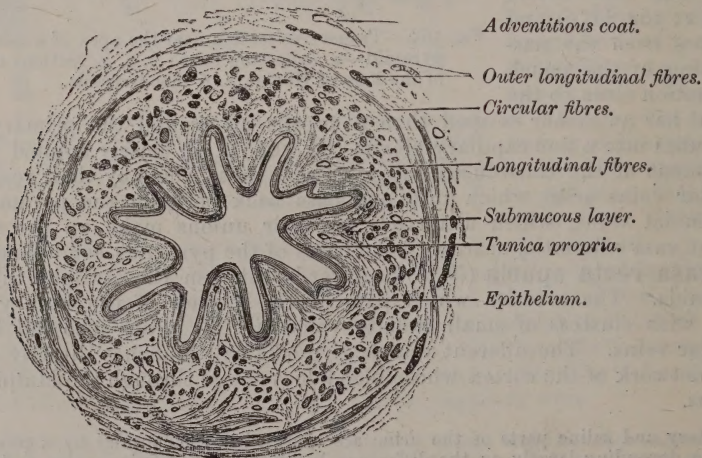


Fig. 567.—Section of the lower part of the ureter.

gastric artery lies above and external to it. In the female the ureters pass on each side of the neck of the uterus, through the plexus of uterine veins and beneath the broad ligament.

In diameter it varies from 3 to 5 mm., being narrowest at its vesical end which burrows obliquely for about 1 cm. through the coats of the bladder; it is also narrow where it crosses the iliac arteries.

In structure it resembles the pelvis of the kidney, but for its lower three-fourths has a second layer of irregularly disposed longitudinal muscular fibres (outside the circular layer).

Its mucosa is pale, longitudinally folded, having only one or two small mucous glands close to its renal end. These glands are lined by a thin layer of columnar epithelium. There is no distinct submucous layer, but in the deep layer of the mucosa there is a large wide-meshed plexus of varicose lymphatics communicating above with those of the kidney. Arteries are few, and derived from the renal, lumbar, and common iliac; nerves are also few, and come from the renal plexus above, from the hypogastric plexus below, and a few ganglion cells are enclosed in the plexus at the vesical end. Its epithelium is transitional, like that of the bladder (fig. 48, p. 24).

Inflate the bladder moderately through the ureter.

300. THE FALSE LIGAMENTS OF THE BLADDER.—The peritoneum which covers the posterior surface of the bladder is reflected in a continuous

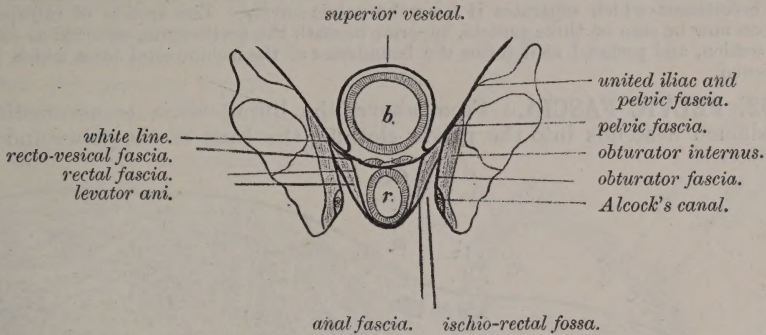


Fig. 568.—Diagram of oblique coronal section through the pelvis, showing the cut outline of the fascia.

sheet from it on the parts around, on the front wall of the abdominal cavity above and in front, and on the rectum behind. This reflection is elevated into distinct folds along three lines. One of these folds is median, extending from the summit of the bladder towards the umbilicus, and contains the urachus (§ 248). This is called the **superior false ligament**. Posteriorly two crescentic folds pass from the wall of the pelvic cavity to the sides of the back of the bladder, one on either side of the rectum. The ureters lie in the bases of these folds, which are named the **posterior false ligaments**. To the sheet of peritoneum between the superior and posterior folds on each side the name **lateral false ligament** is given, and under this layer lie the obliterated hypogastric artery, the vas deferens, and the vesical artery. Between the two posterior false ligaments is the rectovesical cul de sac of peritoneum (p. 392). There is no true line of demarcation between the lateral and the other false ligaments, but the line of the hypogastric artery may be arbitrarily taken as limiting it both behind and in front.

Dissection.—Divide the peritoneum on the right side of the bladder and strip it off the right half of the organ without injury to the underlying layers, remove it also from the right half of the wall of the pelvic cavity, and with the finger and handle of the knife take away the lax connective tissue of the cavum præ-peritoneale (§ 247). Thereby a thin membrane, the upper surface of the pelvic fascia, is exposed.

301. THE TRUE LIGAMENTS OF THE BLADDER consist of pelvic fascia reflected from the pelvic wall on the side of the base of the bladder (fig. 568). The reflection attached to each side of the bladder is the **lateral true ligament**, which is lost in the subserous tissue on the sides and summit of the organ. Traced forwards, this reflection ends on each side of the middle line in a strong short fold, the **anterior true ligament**, which passes from the pelvic wall on the level of the lower end of the symphysis pubis to the front of the bladder above its neck. Between these two anterior true ligaments in the median line is a deep furrow containing very lax tissue

beneath which lies the intrapelvic extension of the dorsal vein of the penis (§ 235). Posteriorly the lateral true ligament becomes thin and indistinct, passing with no abrupt border into the areolar tissue around the rectum.

Dissection.—Before proceeding with the dissection, the arrangements of the fasciæ within the pelvis should be observed. The lower limbs having been removed at the hip-joints, the right ilium is to be sawn through the acetabulum in a line from the upper and anterior part of the sciatic notch to the upper border of the obturator foramen, the spine of the ischium is to be divided at its root, and the right ischium is to be sawn through along a line joining the lower limit of the lesser sciatic notch and the lower limit of the obturator foramen. The piece of bone thus isolated being removed from the *obturator internus* which underlies it, that muscle is to be seized by its tendon and dissected away, leaving intact its fascial investment which separates it from the pelvic cavity. The system of intrapelvic fasciæ can now be seen on three aspects, superior beneath the peritoneum, external as shown in this section, and perineal as it forms the boundaries of the ischio-rectal fossa which is to be reopened.

302. PELVIC FASCIA.—From above, the lining fascia transversalis of the abdomen descends into the pelvis, clothing the back of the pubes and the

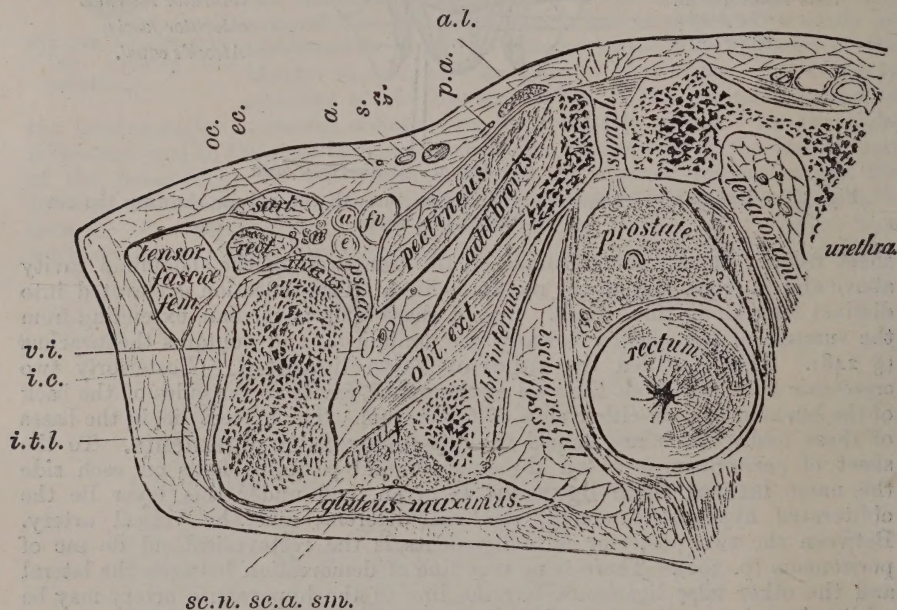


Fig. 569.—Horizontal section of pelvis, showing the obturator and anal fasciæ bounding the ischio-rectal fossa. (The name levator ani is on the obturator muscle along the outer cut border of the right levator ani.)

side of the cavity below the ilio-pectineal line, degenerating into a lax layer of areolar tissue over the *coccygeus* and over the intrapelvic aspect of the *pyriformis* and greater sciatic notch. It is perforated by the branches of the internal iliac vessels, the openings for which are usually bounded by distinct white fibrous bands. This fascia is closely tied to the periosteum along the ilio-pectineal line, where it becomes inseparably attached to the inner edge of the iliac fascia, and it is attached to the hinder surface of the pubes, and laterally clothes the intrapelvic surface of the *obturator internus* as far as the level of a line drawn from the anterior true ligament of the bladder backward to the spine of the ischium. On this level the fascia is thickened and opaque, and a more or less definite streak, the **white line**, marks the place along which the fascia

appears to divide into two descending lamellæ. This white line can be seen either from the intrapelvic or from the outer side.

The outer of these lamellæ (**obturator fascia**) is seen in the lateral dissection to form the sheath of the *obturator internus*, and, viewed from the perineal side, this layer is seen to split along the upper angle of the ischio-rectal fossa (§ 222) into the two fasciæ which bound that space. The outer of these (**proper obturator fascia**) has already been seen completing the sheath for the *obturator internus*, enclosing the third stage of the pudic artery in a canal in its substance, *Alcock's canal*, and attached below to the tuber ischii and falciform edge of the greater sciatic ligament. The inner (**anal fascia**) is the thin indistinct lamella which clothes the perineal aspect of the *levator ani*. Tracing these two layers towards the front of the perineum, they reunite close to the inner edge of the ischio-pubic ramus at the level of the tuber cavernosum, (fig. 569) and the conjoint layer thus formed is attached to the inner and upper edge of the pubic ramus, from this forwards to this symphysis. From this attachment a lamella is continued inwards on the under surface of the anterior (pubic) fibres of the *levator ani*, below and in front of the prostate to the median line, where it joins its fellow of the opposite side in a raphé pierced above and in front by the dorsal vein of the penis, below and behind by the membranous portion of the urethra. This median prolongation is often named the posterior layer of the triangular ligament, but it is better to consider it independently as the **subpubic fascia**. It bears on its perineal surface the fourth stage of the pudic artery and its branches, Cowper's gland, the *compressores urethræ* muscles, and on its upper surface the *levator ani* and the prostate.

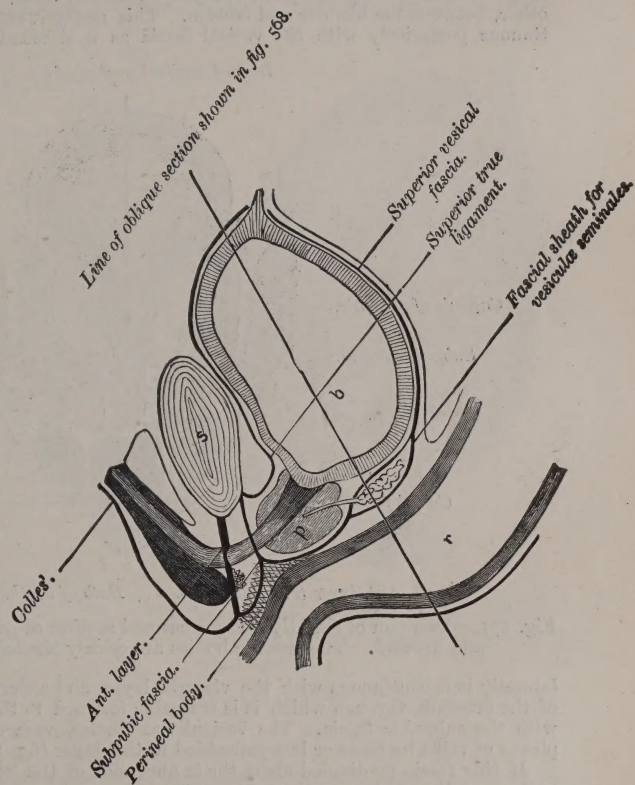


Fig. 570.—Sagittal section through bladder and rectum—r, rectum; s, symphysis; b, bladder; p, prostate.

The upper surface of the origin of the *levator ani* can be seen in this dissection to extend to the white line in the angle of the apparent splitting of the fascia; some of its fibres can be traced into the prostate.

It can also be seen that the *levator* is bilaminar, especially towards its insertion; its superficial part, including most of its pubic part, being on the plane of the superficial sphincter, its deep plane being on the level of the interval between the superficial and deep sphincters.

The anal and medial connection of the *levator ani* are secondary. The muscle is primi-

tively a caudal muscle, and has become secondarily perineal from the suppression of the tail. In tail-bearing animals most of it is the lateral caudal muscle, only a small part and that only in higher forms being set apart as an anal muscle, its innervation on its inner side and from the third sacral nerve marks its segmentation from the sphincter, whose innervation is always on its outer surface.

This muscle separates the outer or obturator system of fasciæ from the inner or visceral which descends on the abdominal surface of the *levator*, and which forms by its superficial lamella the lateral true ligaments of the bladder.

Dissection.—Divide the lateral true ligaments along the side of the bladder, tracing the vesical layer of fascia inwards over the bladder until it degenerates into a thin subserous coat. Draw the bladder forwards and to the left, and thereby expose a thick soft layer of tough areolar tissue permeated with lymphatics and veins, which extends from one side to the other, between the bladder and rectum. This **recto-vesical layer** (Tyrrell's fascia) is continuous posteriorly with the vesical fascia as it descends over the back of the bladder,

Line of sagittal section of fig. 570.

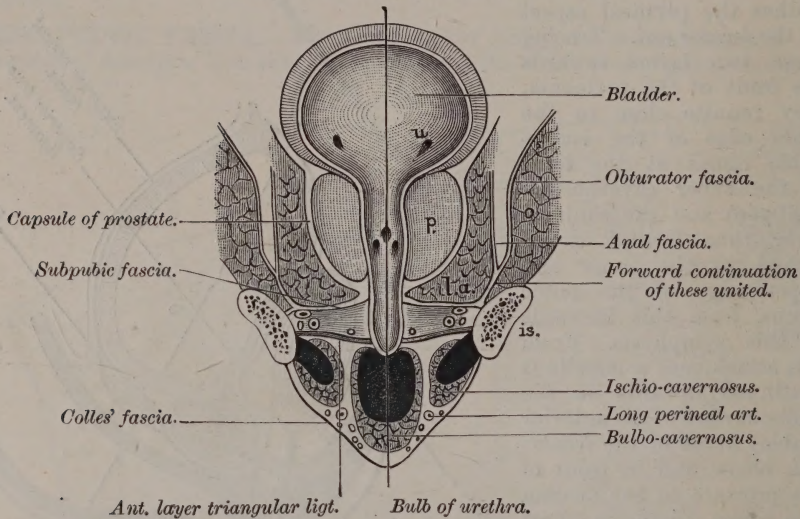


Fig. 571.—Diagram of slightly oblique coronal section of pelvis through bladder, prostate (p) and urethra. The erectile bodies are darkly shaded—u, ureter; is, ischium.

laterally it is continuous with the visceral layer, and anteriorly with the superficial capsule of the prostate, through which it is traceable forward to the front of the *levator ani*, to join with the subpubic fascia. The vesiculæ seminales, vasa deferentia, and prostatico-vesical plexus of veins lie more or less embedded in this layer (fig. 573, T').

If this fascia be divided along the inner side of the *levator ani* as it is about to cover the surface of the rectum, a deep connective process is exposed which dips in between the *levator ani* and the side of the rectum. This **rectal fascia** degenerates below into loose connective tissue on the wall of the rectum.

In development the intrapelvic fasciæ are twofold, obturator and visceral, the obturator fascia is originally an independent layer, derived from the system of the fascia lata, sheathing the *obturator* muscle, with which it is co-extensive. This is covered on its inner surface above the white line by the true pelvic fascia, and becomes inseparable therefrom in the adult. The *levator ani*, whose origin is on the inner surface of the obturator fascia, and which therefore becomes connected with these combined fasciæ at the angle of union, not uncommonly sends fibres of its tendon upwards in the substance of the combined layers, even as high as the ilio-pectineal line, indicating the primitive plane of division. The visceral layer primitively excluded the bladder as a parietal organ from the abdominal cavity. The connection of the recto-vesical with the subpubic fascia is probably secondary; but it must be borne in mind that much of the definiteness of these layers in the adult is created by the knife and forceps.

The relations of the peritoneum and fasciæ to the ureter, the hypogastric artery, and the vas deferens having been reviewed, the superior pubic rami should be removed to expose the bladder, which is next to be examined.

303. BLADDER.—The shape and relations of this organ depend on its degree of distension and on the pressure to which it is subjected by the surrounding parts. In an opened abdomen it appears somewhat ovoid. In sections through the frozen abdomen it appears indented by the parts above it. When emptied by the contraction of its wall, it shrinks and becomes rounded; but when the contraction is imperfect it becomes flattened, either sagittally or vertically, according to its relation to the overlying small intestine. Behind, it rests on the rectum with the intervention, below, of the recto-vesical fascia, the vasa deferentia, seminal vesicles and ureters, and above, of the recto-vesical cul de sac of peritoneum. Anteriorly it is in contact with the pubis and the abdominal wall, to which it is tied by the anterior true ligaments below, and by the urachus and superior false ligament of peritoneum above. Between the true and false ligaments anteriorly is the præperitoneal space in which the bladder is separated from the abdominal wall by exceedingly lax areolar tissue. Laterally the bladder is tied to the side of the pelvic cavity by the lateral false and true ligaments and the parts within them, and below, on each side, lies the prostatico-vesical venous plexus. The convolutions of ileum lie on its upper and posterior surface.

The long axis is nearly horizontal, its base being directed backwards towards the sacrum and its summit towards the upper edge of the pubes. In the female it is nearly as broad as long, the vertical being to the transverse diameter as 9.5 : 10.2; in the male it is longer than broad, its diameter being as 14 : 10.

Its average capacity is about 650 c.cm., but varies in health from 460 to 1,600 c.cm. in the male, and between 320 and 1,300 in the female. The sac suddenly contracts to the urethra without any tapering part or neck intervening. The false and true ligaments having been divided, the serous membrane should be removed from the summit, back, and hinder part of each lateral surface. The closeness of adhesion of this membrane is variable. Beneath the first coat, which is the imperfect investment of peritoneum, is a **second** or **subserous** connective tissue coat, derived from the true ligaments, in which most of the larger vessels ramify, the veins being mostly beneath it and the arteries on its surface.

The **third** or **muscular coat** is the thickest, and is imperfectly divisible into three layers, the outer of which is of reddish *longitudinal* unstriated fibres arranged in several series.

One set are **uracho-vesical** (fig. 572, 2) and radiate in three series; the anterior fibres descend on the front wall (*ib.*, 3), the posterior (*ib.*, 1) on the hinder wall from the urachus, and the lateral pass in two series, some oblique (4) and some directly downwards (5) from the urachus to the prostate. A second set are **pubo-prostatico-vesical**, and radiate on the anterior wall from the attachment of the anterior true ligaments; a third series are **recto-vesical**, coming from the fascia, so named in the male, or **vagino-vesical** in the female. These series freely interlace into a continuous layer, which is sometimes named the *detrusor urinae* muscle.

The middle layer is a thin, irregular stratum of *circular* fibres (shown by removing the longitudinal fibre at 6—fig. 572), which, for the lower half, are

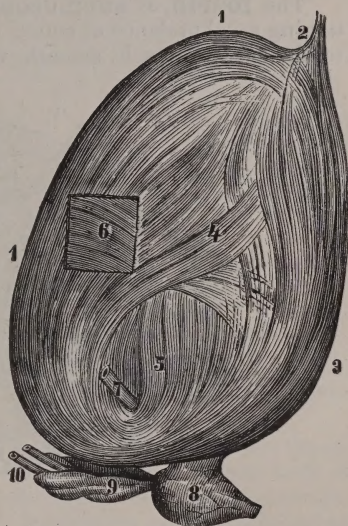


Fig. 572.—Outer layer of longitudinal muscles of the bladder—7, ureter; 8, prostate; 9, vesicula seminalis; 10, vas deferens.

spinal branches, from the inferior lateral prolongation of the hypogastric plexus and from the vesical branches directly from the sacral plexus. They lie chiefly at the sides and base along with the arteries, and have ganglion cells in their meshes; they are distributed in two plexuses—one series, including the branches from the second and third sacral nerves, are distributed in a plexus among the muscular fibres; the second series, which are purely from the sympathetic system, form a close network in the mucosa beneath the epithelial layer, and have been described as sending filaments between the epithelial cells to end in special cellular nerve endings.

The chief vesical arteries are two on each side, one from the internal iliac, distributed to the sides of the organ within the layers of the lateral false ligament. The hypogastric usually gives off a superior vesical, its last pervious branch. Inferior vesical branches come from the pudic.

The vesical veins descend to the large plexus which lies in the lateral true ligaments at the side of the base of the bladder. The lymphatics are few, chiefly found in the region of the trigone, though there are also a few on the anterior wall; they accompany the veins, and end in the inferior hypogastric glands situated with the venous plexus.

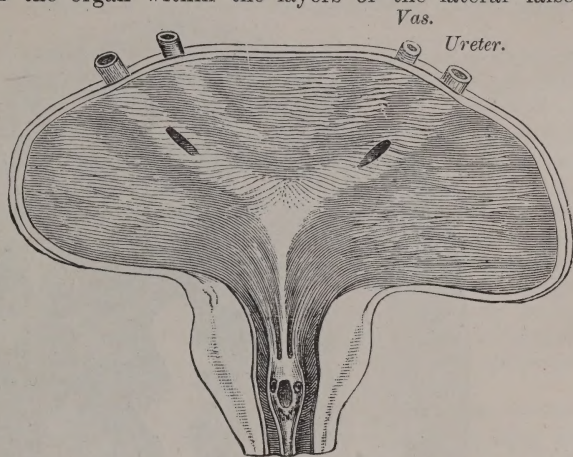


Fig. 574.—Trigone and prostatic portion of urethra laid open.

304. THE VASA DEFERENTIA (fig. 575), which have been already traced up from the testes (p. 383), are to be followed as they descend on the back of the bladder by drawing the bladder forwards and upwards. They converge, each towards its fellow, and form the lateral boundaries of the **posterior vesical triangle**, whose base is formed by the fundus of the recto-vesical peritoneal pouch, and, whose apex is below, where these ducts unite with the duct of the vesicula seminalis, forming the **common ejaculatory duct**, which enters the back of the prostate gland. Each vas is about 2.5 mm. in diameter, but its lumen seldom exceeds 0.6 mm. At the back of the bladder the vas dilates into an **ampulla**, which is saccular and tortuous, containing a few small tubular mucous glands in its coat.

305. THE VESICULA SEMINALIS is external to the vas on each side. These vesiculæ are two irregular, pear-shaped masses of convoluted tubes, each about 5 cm. long, lying between the wall of the bladder and the recto-vesical fascia. Their bases are divergent above, and their apices converge in front, and end in ducts which open at the back of the prostate into the common ejaculatory duct, along with the vas deferens.

If the vesicula be inflated from the vas deferens it can be dissected out as a wide coiled tube about 15 cm. long, from which many saccular diverticula project, which are tied into a solid mass by the surrounding areolar tissue and smooth muscle. Bands of muscle also cross from one vesicula to its fellow beneath the fascia, and some of these are connected to the superficial muscles of the bladder.

The coats of the vesicula are similar to, but thinner than, those of the vas deferens. The mucous surface appears honeycombed, whitish grey, and in the wall are embedded many small tubular albuminiparous glands. The arteries of the vesiculæ are derived from the inferior vesical branches of the pudic; the veins pass into the prostatico-vesical plexus; the lymphatics are very numerous, and end in the middle hypogastric glands; a plexus of nerves

containing ganglion cells lies in the coats of the vesicula, derived from the hypogastric plexus.

Dissection.—Divide the inferior pubic ramus by a vertical incision 1 cm. to the side of the symphysis, and draw the bladder a little backwards and upwards. Remove the prostatico-vesical veins from each side of its base, and having followed the vesiculæ seminales and vasa deferentia to their junction at the prostate, clear the sides and under surface of the prostate gland.

306. THE PROSTATE (figs. 569, 572) is a firm, chestnut-shaped muscular and glandular mass surrounding the first part of the urethra, having its base (*facies vesicalis*) directed upwards, covered by the bladder. Its narrow end is

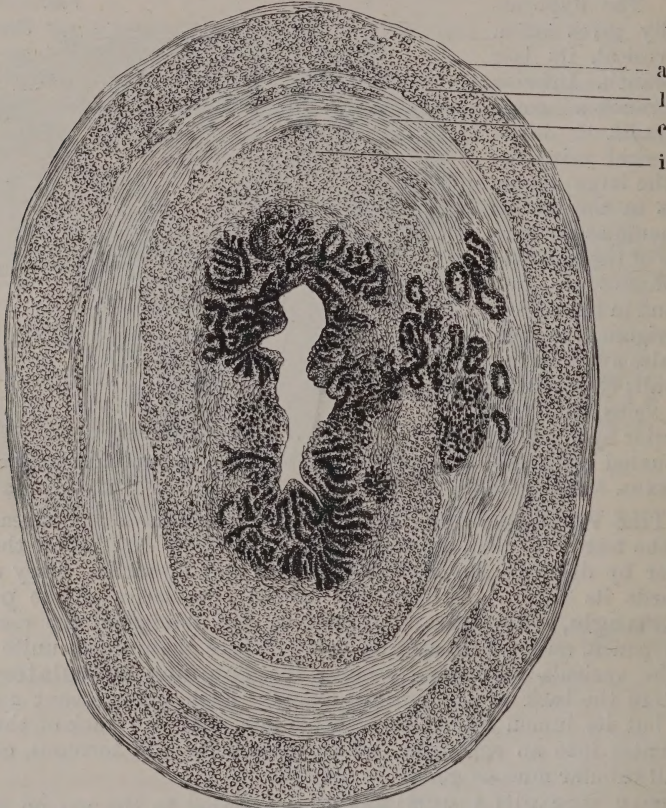


Fig. 575.—Section of vas deferens, $\times 50$ —a, areolar coat; l, longitudinal muscle; c, circular nerve; i, submucous tissue under mucosa, and containing glands.

turned downwards and a little forwards, and lies on the subpubic fascia. The hinder (largest) side (*facies rectalis*) is smooth and flattish, separated from the rectum by a prolongation of the recto-vesical fascia, but it can easily be felt by the finger introduced into the rectum about 6 cm. above the anus. Its front surface (*facies pubica*) is nearly 1 cm. behind, and a little below the symphysis pubis, usually marked by a shallow median groove, and having the lower and inner part of the anterior true ligaments of the bladder attached to it. Its sides are in contact with the anterior edge of the *levator ani* muscle anteriorly, and with the prostatico-vesical plexus of veins behind.

Its largest diameter is transverse at the base, measuring 3.5 to 4.5 cm.; vertically along the urethra it measures 2.5 to 4 cm., sagittally 2.5 cm. Its weight averages 22 grammes,

and its volume 18 c.cm. The urethral canal is 6 mm. from its anterior, 8 mm. from its posterior surface, and is 3.5 cm. long where it traverses the gland. The two ejaculatory ducts notch its upper and back border as they sink into it.

The normal prostate is a single mass, but is sometimes artificially divided into three lobes, two lateral and one median posterior, the latter consisting of that portion of the gland which lies between the ejaculatory ducts and the neck of the bladder, and whose projection, bladderwards, lies beneath the mucous membrane of the uvula vesicæ. This portion (**Home's lobe**) is the commonest seat of senile enlargement, in which condition only is the trilobation externally apparent.

The outer sheath (**pelvi-prostatic capsule**) derived from the recto-vesical fascia covers the prostate. Embedded in this fascia are those veins which pass from it to the prostatico-vesical plexus, among others the lateral extension of the dorsal vein of the penis. Beneath these veins it is possible by dissection to expose the outer surface of the organ, which appears invested by a dense but thin fibrous coat, with difficulty separable from the overlying fascia, and continuous internally with the scanty interstitial areolar tissue. The mass of the prostate consists of unstriped muscle, arranged in three rather indefinite strata. The outer series of muscle cells are chiefly disposed transversely, the middle are for the most part radial, and the innermost are circular, connected with the circular fibres of the bladder behind, and with those of the urethra in front, and forming the *sphincter vesicæ internus*, to distinguish it from the striped muscle envelope at the apex of the prostate, which is called the *sphincter externus*. The pre-urethral isthmus is entirely made up of muscle.

The glandular element of the prostate amounts to about 23 per cent. of the whole mass, and consists of a series of slightly branched tubules, ending in tubular alveoli, which are convoluted in the lateral and lower parts, shorter and wider in the middle lobe. These tubules are lined by columnar epithelium, with a rather thick layer of intermediate cells resting on the basement membrane around their attached ends. The glandular tubules are arranged in three sets corresponding to the three lobes of the gland, separated by areas of pure muscle, to which element the uniform outline of the gland is due. The muscular tissue is laxer towards the apex than towards the base of the gland. The glandular tubules unite into three sets of ducts, which open into the prostatic portion of the urethra, about eight or ten laterally, and about three or four from the middle lobe, nearer the middle line on each side of the colliculus seminalis.

The arterial supply of the prostate is proportionally small, derived from the inferior rectal and vesical arteries. Its veins are large, and form a frequently anastomosing plexus. The lymphatics also are large, and communicate with a lymphatic gland, which lies in the lateral true ligament of the bladder. The nerves, mostly non-medullated, come from the hypogastric plexus, along the branches of the vesical artery. A few medullated fibres ramify on its surface, some of which end in Pacinian corpuscles.

307. URETHRA.—By slitting up the pre-urethral portion of the prostate, the first part of the urethral canal is exposed (fig. 574). The whole tube is about 22 cm. long, and of composite origin, divisible into three stages. The first or prostatic stage descends nearly vertically, and corresponds to the posterior ventral part of the urogenital sinus of the cloaca, which receives the Wolffian and Müllerian ducts. The second or membranous part passes forwards, piercing the subpubic fascia and the anterior layer of the triangular ligament, and the third or spongy portion ascends through the front of the perineum, and descends in the penis to the orifice. These two are portions of the anterior region of the cloaca closed into a canal by a superficial median union of the tegu-

mentary folds which formed the borders of the cloacal fissure, whose dermis is here modified into an investment of erectile tissue.

The prostatic portion is the widest part of the urethra, broader in the middle than at either end, and is crescentic in coronal section. Its floor is elevated into a rounded elongated ridge, about 2.2 cm. long, the **colliculus seminalis** (*verumontanum*, fig. 574), the summit of which is excavated medially by a long and variably deep pouch, the **sinus prostaticus**, formed of the united ends of the rudimentary Müllerian ducts. This pouch is about 1 cm. deep and 2 mm. wide at the mouth, 4 mm. at its fundus, which is often bifid, and stretches backwards nearly through the thickness of the gland.

On each side of this the two common seminal ducts open. These tubes, formed by the junction of the vas deferens with the duct of the vesicula on each side, are about 2 cm. long, very much narrower than either of the component ducts, and very thin walled. They transverse the prostate, converging to the sides of the colliculus, and open by two fine slit-like orifices. They have no outer areolar coat, a very thin muscular wall of fibres becoming reticular towards the urethra, and the rugæ, which are continued from the vas into the commencement of the duct, soon disappear, as do also the mucous glands.

In the valleys on each side of the colliculus, about 14 ducts of the prostatic gland follicles open, some of them from the so-called middle lobe piercing the sides of the colliculus. The colliculus begins at the orifice of the bladder as

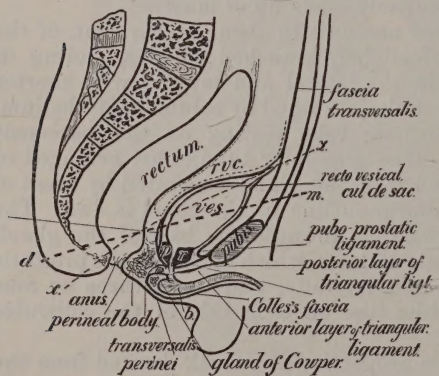


Fig. 576.—Sagittal section of bladder and urethra—*m, d*, line of section to fig. 568; *rvc*, recto-vesical cul de sac of peritoneum; *b*, root of scrotum.

the uvula, and ends below by becoming a low ridge (**frænulum colliculi**) that finally dies away in the membranous portion. No prostatic ducts open on the front wall or concavity of the crescent of the urethra. The mucous membrane of the prostatic portion of the urethra is longitudinally folded, is lined by transitional epithelium, and has a layer of longitudinal and one of circular muscular fibres below its corium. The prostatic sinus is lined by pavement epithelium.

The second portion of the urethra or **membranous** portion is that part which traverses the space between the *levator ani*, the subpubic fascia, and triangular ligament, running obliquely forwards and downwards about 2 cm. under the pubes;

it is about 17 mm. long, but is overlapped for 11 mm. of its lower surface by the bulb, the portion of which lying beneath it is the **colliculus bulbi**. It is the narrowest portion of the canal, and appears circular in section, with a stellate lumen due to the longitudinal folding of the mucous membrane. It is surrounded by the *compressor urethræ* muscle and lies above and internal to Cowper's glands (fig. 480). When distended so as to obliterate its folds the diameter is 5 mm. It has the central perineal tendinous point behind it, and the dense tissues attached thereto separate it from the rectum.

Beneath the striped fibres of the *compressor urethræ* is a thin layer of erectile tissue, under which the mucosa is surrounded by a layer of circular fibres, continuous from the outer lamella of the prostatic musculature; still deeper is a thin layer of longitudinal fibres, and there is some cavernous tissue

in the corium also. The epithelium has become stratified columnar on this part of the tube.

The third or **spongy portion** of the urethra is from 15 to 18 cm. long, and begins in front of the triangular ligament. This portion is surrounded by the erectile tissue of the corpus spongiosum urethræ, which begins posteriorly as the bulb of the urethra (fig. 571), coats the wall of the tube, and ends in front in the glans penis. The bulb is imperfectly divided into two hemispheres by a superficial groove, and a membranous partition which here separates the erectile tissue into two lateral masses. This tissue is similar to that of the corpus cavernosum (fig. 139, p. 81), but its meshwork of fibres is finer, its capsule more elastic, its spaces smaller. Helicine arteries are numerous in the bulb, but diminish towards the glans in which there are few. The blood is derived from the large arteries of the bulb, and still further forward from the accessory arteries of the corpus spongiosum from the pudic. The veins from the glans end in the dorsal vein of the penis, those from the bulb pass partly into the pudic vein, partly into the prostatic plexus. The nerves are from the hypogastric plexus.

The erectile tissue coats chiefly the underside of the urethra, which is at first a transverse slit in section (figs. 490, 491), becoming T-shaped, and finally appearing as a vertical slit in the glans towards the meatus. The lumen of the tube is wide at the bulb, the **pars bulbosa** having a circumference, when undilated, of 1.7 cm. for about 1 cm., then becomes narrower (1.6 cm.) to the base of the glans where it widens into the **fossa navicularis**, an enlargement about 2 cm. long, directly before the tube ends at the meatus, and with a circumference of 1.9 cm. The orifice is a very narrow slit 5 mm. long, bounded by two lateral lips, and is the least dilatable part of the tube.

The mucosa is lined by a columnar stratified epithelium as far as the beginning of the fossa navicularis, where the surface layer becomes one of squamous cells, with a papillose basement. Outside the corium is a vascular erectile layer, invested by longitudinal and circular fibres, outside which is the tissue of the corpus spongiosum.

The mucosa is studded by minute glandular follicles, glands of Littre, and is depressed into small pits or **lacunæ**, with obliquely valvular mouths, which are especially large on the floor of the bulbous region. The largest lacuna (**l. magna**) is on the upper surface of the fossa navicularis, whose valve-like lower wall is called the valve of the fossa navicularis.

The surgical anatomy of the urethra is of great importance. To permit of the passage of large instruments in lithotomy it is often necessary to slit the orifice, which is very slightly dilatable. In passing very fine catheters the point may become entangled in the lacuna magna or other lacunæ, in the sinus of the bulb, or even in the sinus prostaticus. Spasmodic stricture is most common in the membranous portion, organic stricture in the bulbous part, where the submucosa is the most extensible, and, when the subject of inflammatory action, is therefore more predisposed to undergo a greater amount of tumefaction, and to be the subject of exudation than elsewhere. In lateral lithotomy the surgeon endeavours to make his knife enter the membranous part of the urethra behind the bulb, without wounding any of the vascular structures of the spongy part of the urethra.

308. FEMALE UROGENITAL ORGANS.—The parts bounding the urogenital rima have been already noticed. The internal parts to be examined are the vagina, uterus, ovaries, and the collateral structures.

The **urinary bladder** of the female is placed between the vagina and uterus behind and the pubes in front, but is separated from the pubes below by a quantity of loose areolar tissue and fat. When empty and relaxed it is vertically pressed downwards and *nearly horizontal*, flattened by the pressure of the small intestines; during pregnancy it is pressed upwards and forwards, and

the peritoneum stripped from its back. Its ligamentous folds of peritoneum are like those in the male, but the posterior are uterovesical and very feebly prominent. The base of the bladder rests on the isthmus and front of the neck of the uterus, and on the upper quarter of the vagina, to which its wall is closely adherent.

The urethra is about 4 cm. long, about 6 mm. in diameter, but very dilatable; it takes a curved course downwards and a little forwards, and is firmly attached to the anterior wall of the vagina; it is widest at the neck of the bladder, but narrower as it passes through the triangular ligament and between the crura clitoridis, to open at the meatus between the nymphæ. There is a dilatation on the hinder wall of the canal, behind the meatus which is its narrowest part.

The wall consists of (1) muscular fibres continuous with those of the bladder, and overlaid behind the triangular ligament by the *compressor urethrae*; within this is a whitish mucous membrane, with one median permanent longitudinal fold and several temporary rugæ, covered for its upper half by transitional epithelium, for its lower by stratified squamous epithelium, and dotted with mucous glands, especially near the bladder, where it is soft and thick; the glands near the orifice are thicker and in groups. Wide crypts or lacunæ occur within the orifice.

Outside the mucosa is an elastic vascular submucosa covered by an imperfect erectile lamella. Its blood, nerve, and lymph supply are connected with those of the vagina. On each side of the urethra is a very fine rudimental canal, occasionally opening close to the

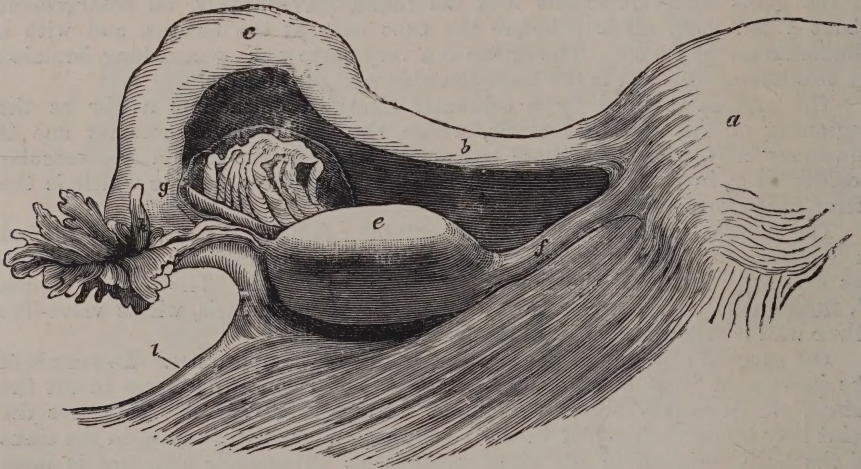


Fig. 577.—Broad ligament seen from behind.

meatus. These are the canals of Gärtner, the rudiments of the Wolffian ducts, but usually impervious. Minute tubular outgrowths from these (Skene's tubules) represent the vesiculae seminales.

The external female organs have been already examined (p. 362), and should now be revised, after which the student should proceed to the examination of the internal organs, which may be examined by the same method as that used in the male to exhibit the bladder.

309. THE UTERUS lies behind the bladder, and from its lateral edge there passes out on each side a peritoneal fold (**the broad ligament**), at the posterior and lateral part of which is the female sex-gland, the **ovary**.

The ovary (fig. 577, *e*) is an oval, flattened, whitish body attached to the broad ligament by its anterior border (*margo rectus*), where its vessels enter, and along the edge of which is a white line, marking the level at which the pavement epithelium of the peritoneum stops, and is replaced by columnar (germinal) epithelium. It is free on both surfaces, one of which is the external, the other

internal, and along its hinder border (*margo convexus*). It is narrower below than above.

The ovary lies in a pouch (**bursa ovarica**) at the back of the broad ligament, and is behind and below the Fallopian tube or oviduct which arches over it. Its long axis is oblique, and it lies a little below the pelvic brim, often in a parietal recess (*ovarian fovea*) on the lateral wall of the pelvis, between the iliac arteries in front of the sacro-iliac joint. The first pregnancy *displaces these parts, and they seldom return as they were. The ovary is fixed to the pelvic wall by a fold derived from the outer and back part of the broad ligament, the **ovario-pelvic fold** (fig. 577, *i*), to the uterus by a connective cord containing smooth muscle, the **ligament of the ovary** (*ib.*, *f*), and to the extremity of the Fallopian tube (*ib.*, *g*) by the **infundibulo-ovarian fimbria**. On cutting off a portion of the ovary it is seen to consist, under the columnar epithelium (fig. 578, *e*), of a fine connective tunica albuginea, under which is a spindle-celled layer of the **zona parenchymatosa** or stroma (*ib.*, *s*), whose elements are somewhat radially arranged, containing embedded in it a number of follicles from .02 to .25 mm. in size, the **Graafian follicles** (*ib.*, 1, 2, 3), of which the largest are internal, but grow towards the surface.

Within the ovary is a central **zona vasculosa**, containing numerous plexiform vessels, joined together by a little connective tissue and smooth muscle.

In the foetus at birth the ovary is large and lobulated. Its surface is smooth until puberty, after which, owing to the shedding of the ova, it becomes scarred.



Fig. 578.—Section of ovary, $\times 30$.

The ovary of a multipara averages about 3 cm. long by 1.5 by 9 mm. thick, but in a young woman it is a little larger; its weight is about 6 grammes; its volume is about 4 c.cm.

In a section of the fetal ovary, processes of the germinal epithelium can be seen sinking into the stroma. In the ovary of an embryo of the fourth month such pouches of the epithelium can be seen indenting the underlying connective stroma. These pouches, by branching, form an epithelial network in the stroma, which, as the ovary grows, become detached as nests of cells in the organ. From each of these nests a Graafian follicle arises.

Each Graafian follicle consists of—(1) a tunica fibrosa or the differentiated envelope derived from the adjacent part of the stroma, which consists of fine connective tissue with spindle cells; (2) a very delicate structureless membrana pellucida; (3) an irregular thick epithelial layer of columnar cells, the membrana granulosa, which at one part is thickened, forming the discus proligerus; (4) within this is a drop of clear *liquor folliculi*, in which floats a nucleated cell, the ovum (fig. 3, p. 4).

Rupture of a Graafian follicle occurs at each menstrual period, and the cavity of the burst follicle becomes filled with an exudation of a peculiar reddish-yellow colour, becoming cicatricial tissue, with a radial arrangement of its fibres, formed by the infiltration of the stroma cells and the follicle, and their proliferation as a folded wall, **corpus luteum**,

which gradually diminishes by the growth into it of normal stroma cells after the tenth day, but does not disappear for about two months. If the ovum become impregnated the corpus luteum is large, and shows a trace of a central cavity owing to the increased vascularity of all the parts, and does not disappear for about eight months. Some few follicles collapse and shrivel without rupture.

The smallest Graafian follicles have their walls undifferentiated, and consist simply of the nests of germinal epithelium and the primitive ovum. There are about 70,000 in the ovaries of a female child at birth; each is at first from .02 to .25 mm. in diameter. The largest differ chiefly in the amount of fluid, and the multiplication of the epithelium of the membrana granulosa. Around each follicle is a plexus of capillary vessels converging towards the most prominent part, the stigma, where, when the follicle is matured, it ruptures.

The ovarian artery, having entered the broad ligament, supplies—

- (1) Branches to the Fallopian tube—(A.) to the ampulla tubæ; (B.) to the isthmus.
- (2) Branches to the ovary.
- (3) Branches to the round ligament.
- (4) Branches to the fundus uteri, the largest branches.

310. THE FALLOPIAN TUBES (fig. 577, c) are the upper portions of the Müllerian ducts, and are enclosed in the uppermost edge of the broad ligament.

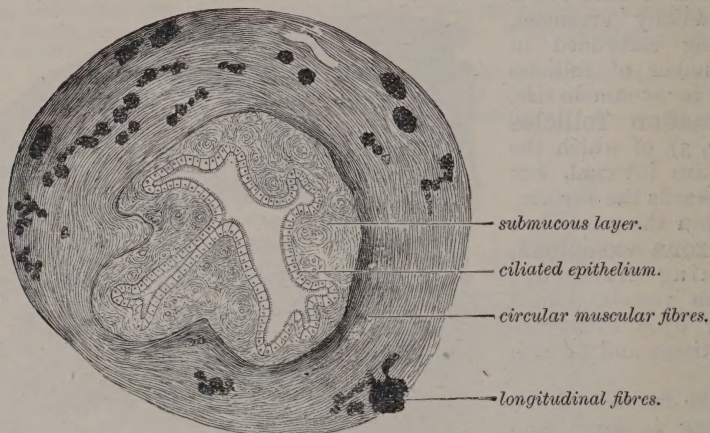


Fig. 579.—Section of a Fallopian tube, $\times 10$.

Each tube begins in a free fimbriated extremity (*ib.*, *g*) with deeply divided margins, one process of which, the **infundibulo-ovarian fimbria**, is attached to the ovary. The aperture of the tube, **ostium abdominale**, is surrounded by this fringe of processes, and is connected with the surface of the ovary by a gutter-like groove along the border of the attached fimbria. The tube, at first dilated into an ampulla, narrows as it passes inwards towards the uterus (*b*), and its inner part or **isthmus** is sinuously bent backwards and attached to the upper and outer angle of the body of the uterus. The entire tube is about 10 cm. long, and its lumen is 3 mm. in diameter at its outer third at its ampulla, and 1 mm. in diameter at its uterine opening.

The wall of the tube consists of (1) a serous layer which at the ostium abdominale communicates with the mucous lining, the only large opening in any serous sac in the body; (2) a subserous areolar layer; (3) a layer of unstriated longitudinal muscle; (4) a layer of circular muscle; (5) a mucous lining, longitudinally folded at the ampulla, irregularly netted at the isthmus, and continuous with the uterine mucosa. It is lined by columnar ciliated epithelium, and similar cilia clothe the stouter columnar cells on the inside of the fimbriæ, and even extend on the squamous cells of the peritoneum on the outer surface. The lumen of the isthmus is stellate.

At the fimbriated extremity, there project one or more stalked cysts about 1.3 mm. in diameter, the **hydatids of Morgagni**, possibly the remains of the terminal sacs of the Müllerian duct.

311. PAROÖPHORON (fig. 577, *d*).—Between the layers of the broad ligament and in the interval between the Fallopian tube and the ovary are several fine tubes running nearly parallel to each other, and communicating with a single stem-tube which runs nearly parallel to the Fallopian. This rudimental organ is the paroöphoron (organ of Rosenmüller), and its tubes, quite closed and functionless in the adult, constitute the residuum of the Wolffian body in the adult female, while the duct is the Wolffian duct. Vesicular swellings sometimes project in the course of this tube, and may be the seat of cystic enlargement.

Small detached groups of tubular vestiges are always present, and sometimes are very distinct between the paroöphoron and the ovary—these are called the **epoöphoron**.

312. ROUND LIGAMENT.—From the upper and anterior angle of the uterus on each side there passes a solid cord, the round ligament, composed of areolar tissue, unstriped muscle, and blood vessels. Each ligament is about 13 cm. long, and passes forwards in the broad ligament across the external iliac vessel and behind the epigastric artery, to enter the internal abdominal ring. It descends in the inguinal canal to the external ring, through which it passes to be lost in the connective tissues over the pubis.

It carries with it into the internal ring in the child a tubular process of peritoneum, the process of Nuck; which, however, is rarely traceable beyond the middle of the inguinal canal, and usually disappears in the adult. It may, however, remain, and be the seat of congenital hydrocele in the female. This cord takes the course of the spermatic cord of the male.

The uterus and all its appendages begin to grow rapidly at and after the first menstruation; the uterine mucosa especially thickens during each menstrual period, and becomes engorged, losing its epithelium, and often part of its subepithelial layer.

313. THE UTERUS is the thickened confluence of the Müllerian ducts (p. 17 and fig. 37) for the reception, nutrition, and subsequent expulsion of the fetus. It is a flattened pear-shaped, muscular organ in the pelvic cavity, consisting of a body above, an isthmus or middle contracted portion, and a cervix below. The upper convex extremity of the body (*fundus*) is directed upwards and a little forwards, and lies on a plane a little below the pelvic brim, in contact with the small intestine. It is usually pushed a little to the right by the sigmoid flexure. The posterior surface of the body is convex, the anterior flattish; both are covered by peritoneum. The front surface of the isthmus is in contact with the bladder, but the posterior surface is covered by peritoneum. The lower third of the cervix projects into the cavity of the vagina; the middle third is, in front, attached to the base of the bladder, but posteriorly projects into the vagina; the upper third is supravaginal and covered by the bladder in front, but covered by peritoneum behind.

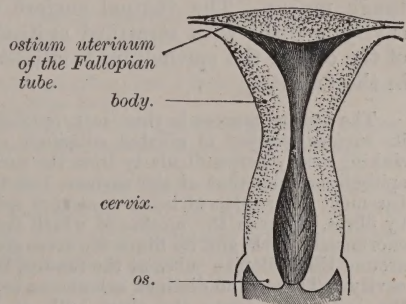


Fig. 580.—Coronal section of uterus.

The peritoneum is reflected from either side of the uterus as the broad ligament, which is attached externally to the pelvic wall. In front of this is the utero-vesical pouch medially and the para-vesical pouch laterally; these are separated by two obscure utero-vesical folds, wherein are utero-vesical

unstripped muscular bands, and below these, and embedded in the subjacent veins, are the ureters. Behind the broad ligaments is the recto-uterine cul de sac (pouch of Douglas), whose deepest part lies between two crescentic recto-uterine folds of peritoneum, which also contain bands of unstripped muscle, the *retractores uteri*. In the uppermost border of the broad ligament is the Fallopian tube. In its anterior portion is the ligamentum teres, and projecting from it posteriorly is the ovary fastened to the uterus by the connective *ligament of the ovary*. The fold of peritoneum covering the ovary, and extending thence to the pelvic wall, is the **ovario-pelvic ligament**, between which and the rest of the broad ligament is the **bursa ovarica**. The lower thicker part of the broad ligament contains the uterine arteries and smooth muscle.

The direction of the uterine axis varies with the conditions of the bladder and rectum, when both are empty the fundus is directed forwards and upwards, the axis nearly coinciding with that of the brim of the pelvis.

On opening the upper part of the vagina the cervix presents a narrow transverse slit, the **os uteri**, whose anterior lip is thicker, its posterior longer. After pregnancy the os becomes rounded, irregular, and puckered.

The adult uterus, before the first pregnancy, is about 80 mm. long by 36 broad and 25 thick; after successive pregnancies it becomes about 90 by 58 and 32. Its volume is in the first condition 30 c.cm., and in the second 60 c.cm., and its weight is respectively 40 and 90 grammes. During pregnancy the organ increases thirtyfold in size and weight, and its musculature becomes distinct and laminated.

To see the interior of the uterus separate it from the bladder and divide its front wall a little on one side of the middle line from fundus to os, and remove a little of the anterior wall so as to open the two cornua of the body. The cavity is proportionally very small, triradiate in the virgin, trigonal in the multipara, and divided by the constriction of the isthmus (os internum) into the cavity of the body and that of the cervix. The latter is spindle-shaped, lined by a pale mucous membrane, and marked by a longitudinal ridge along both its anterior and posterior part, from which there diverge a series of irregular oblique ridges, the whole making the **arbor vitæ uterina** (fig. 580), between these ridges are mucous follicles, the **glandulæ Nabothi**, which secrete a tough mucus. The vaginal surface of the cervix and the lower third of its cavity is lined with stratified epithelium on a papillose corium. For the rest of the cervix the epithelium is ciliated columnar on the ridges, simply columnar in the furrows.

The uterine mucosa is thin, soft, reddish, smooth in the multipara, and closely adherent, its surface consists of ciliated columnar epithelium, and is dotted with tubular follicles, sinking nearly perpendicularly from the surface. These are lined for most of their extent by epithelium, like that of the surface, but their alveoli are filled with irregular cells. The basement and subjacent layers consist of spindle-shaped cells in a ground-substance traversed by fibres, between the meshes of which are large lymph spaces. The muscularis mucosæ is enormously thick, and its fibres are arranged circularly in the isthmus and in concentric rings around the Fallopian tubes at the fundus, becoming more irregular towards the middle of the cavity. There is no distinct submucosa separating this from the muscular coat, which, with the last layer, forms the chief bulk of the uterine wall. This, in the unimpregnated uterus, is inseparable into lamellæ, but consists of fibres $\frac{1}{4}$ mm. long; but in the gravid uterus the fibres become $1\frac{1}{2}$ long and arranged in two strata, an outer of transverse and oblique fibres, and an internal of irregular oblique fibres. In old age all parts become atrophied.

The **vagina** is a membranous passage beginning within the nymphæ or labia minora, and ending above by embracing the cervix uteri. It is widest medially and narrows to each end. Its axis is curved upwards and backwards, nearly parallel to the conjugate axis of the pelvic brim, and forms an angle of 70° with the horizon. Its walls lie in contact, one anterior, 6.5 cm. long, and one posterior, 9 cm. long. Each forms around the cervix uteri an anterior and

posterior fornix vaginae. These walls are broader above than below, and present a rough inner surface, the anterior wall being transversely rugous; the rugæ diverging from a central ridge, **carina vaginae**, and the posterior having two vertical **columnæ rugarum** and many transverse rough lines.

In structure the vagina consists of a stratified scaly epithelium, a dense corium, with many papillæ and glands, a vascular erectile lamina, with many venous plexuses, a layer of unstriped circular muscle and one of longitudinal unstriped muscle, and a dense outer areolar layer. Outside this is the striped sphincter vaginae, at the vulval end of the passage only, not extending beyond the triangular ligament.

The lymphatics of the vulval end of the vagina communicate with the inguinal glands; the uterine mucosa is like a great lymphatic follicle, and in its deep layer the many lymph spaces communicate with lymphatics, which end in the lateral uterine glands in the broad ligaments. There are very few lymph spaces in the muscular wall, but there are lymph sheaths around the vessels. The lymphatics of the cervix uteri pass to pelvic glands close to the internal iliac artery.

The very free arrangement of lymph spaces in both uterus and vagina explains the rapid absorption of septic matter from the uterine and vaginal surfaces.

314. DEEP STRUCTURES ON THE HINDER WALL OF THE ABDOMEN.—The **suprarenal bodies** are two flattened, yellowish-brown organs, surrounded by a loose areolar and fatty layer, and in contact with the upper and inner margins of the kidneys. The right is triangular, with rounded angles, averages 4·5 cm. long by 2·4 cm. broad, and lies behind the liver, which it compresses; the left is somewhat crescentic, about 5 cm. long by 2·5 broad, and lies behind the pancreas and spleen (fig. 546).

The upper edge of each is thin, and projects forwards and inwards; the lower is concave, thicker, deeply indented along a line, the **hilum**, where the vessels enter and leave. The arteries are three—a superior from the phrenic (p. 421), a middle from the aorta (p. 423), and an inferior from the renal (p. 423). There is one suprarenal vein on each side, the right ending in the vena cava, the left in the left renal. Lymphatics are very numerous, and join those from the upper part of the kidney. The nerves are also abundant, and are branches from the aortico-renal and semilunar ganglia.

On the right a few branches pass from the phrenic ganglion, but I have failed to find any filaments from either the phrenic or vagus nerve in either body.

The body varies in bulk at different ages. It weighs about 19 grammes in the adolescent and young adult, diminishing to 14 grammes in middle life, and atrophying with old age.

The suprarenal body consists of two strata—a cortical, or outer, which is thick, yellow-brown, and striated; and a medullary, or inner, which is soft, thinner, deep brown. The body is invested by a firm, inelastic capsule, which sends in processes, **trabeculæ**, through the cortical layer. These unite into an imperfect **limiting layer** of loose areolar tissue between the cortical and medullary layers.

The trabeculæ form meshes which vary in shape at different depths. Near the surface the meshes are polygonal, and are filled up with granular cells like gland-cells. This portion is called the **zona glomerulosa**; beneath it is a thicker **zona fasciculata**, in which the meshes are elongated, and whose radiating outer spaces are filled with clear, oil-globule-holding cells. The inner stratum is the **zona reticularis**, and contains in its meshes pigmented cells. These zones differ chiefly in the disposition of the trabeculæ, and are not marked off from each other by hard and fast lines.

The medullary matter consists of irregular brownish cells, with no oil globules, arranged in a much finer trabecular network, in which also are distributed very many nerve filaments with bi- and multi-polar ganglion cells. The arteries which enter the cortical layer end in venous capillaries in the medullary substance within which the suprarenal vein originates.

There is a layer of longitudinal smooth muscle cells on each venous radicle, continued outwards on the suprarenal vein.

In development the suprarenal body is twofold. The medullary matter is an outgrowth of the abdominal system of sympathetic ganglia, around which the cortical matter originates by a rapid growth and thickening of the sub-peritoneal tissue around the segmental tubes of the metanephros. This modification is probably due to the taking on, by this part of the Wolffian body, of some secondary function, or the loss of its secreting function. What that secondary function is we do not as yet know. Its structure and development show that it must have some connection with the sympathetic system, while the fact that pigments in different conditions of degeneration occur in the cortical and in the medullary matter seem to indicate that the organ takes some part in the destructive decomposition of pigment matters.

Abdominal Sympathetic System.—On removing the viscera from the deep wall of the abdomen two series of sympathetic nerves are exposed—the system of the great splanchnic nerve and the lumbar chain of ganglia.

The **great splanchnic nerves**, whose origins have been already seen (p. 352), escape through special openings in the diaphragm beside the crura. Each nerve passes inwards and a little forwards across the adjoining crus, the right lying behind the inferior vena cava, and the left behind the pancreas. Each nerve ends in a large cluster of united ganglia of irregular shape, which is called collectively the **semilunar ganglion**. Each of these lies internal to the line of the splanchnic nerves, the right on the right crus, the left on the left side of the aorta, and they are united by thick branches around the celiac artery, so making a great central **celiac or solar plexus** which extends from one suprarenal body to the other across the aorta, inextricably interwoven with the celiac lymphatic vessels and glands.

From the margins of this plexus branches stream in various directions. These form two series, those from the concavity of the plexus which surround and accompany the branches of the celiac artery, and those from the convexity. The former are in three groups—

1. The **gastric plexus** accompanies the gastric artery around the lesser curvature of the stomach, and its branches freely communicate with the gastric plexus formed by the two vagi. Minute ganglia lie here and there in the meshes of this plexus along the trunk artery; the branches passing off from this plexus form the chief part of the minute plexuses in the gastric wall.

2. The **hepatic plexus**, much larger, consists of three sets of large, often uniting, clusters of nerves which accompany the hepatic artery.

While it is in the right pancreatico-gastric fold it gives off—(a.) a small plexus around the common bile duct; (b.) a similar series around the vena portæ, in the fœtus sending branches around the ductus venosus and umbilical vein.

In the lesser omentum it is joined by a branch of the right vagus, and sends off—(c.) the superior right gastric plexus, around the superior pyloric artery. This joins the gastric plexus, and receives branches from the left vagus; (d.) an inferior right gastric plexus descends on the gastro-duodenal artery and along the right gastro-epiploic, giving off both gastric and omental branches; (e.) the pancreatico-duodenal plexus accompanies the last, and is distributed along the pancreatico-duodenal artery. Its branches form Auerbach's and Meissner's plexuses in the duodenum, and also form a plexus in the coats of the pancreatic duct, and accompany the small vessels into the head of the pancreas (f.). The terminal hepatic filaments chiefly accompany the branches of the hepatic artery into the liver.

The nerves of the gall-bladder are twofold—one set derived from the series f. accompanies the cystic artery; another set, more numerous, from a. accompanies the duct. These latter form an Auerbach's plexus in the wall, between whose branchings there are ganglion cells for a little more than the half of the sac nearest to the fundus, but none near to the neck.

3. The **splenic plexus**, still larger than the hepatic, consists of two closely united series of branches, which accompany the splenic artery leftward. This sends off (a.) pancreatic branches to the body of the gland; (b.) the inferior left gastric plexus, along the left gastro-epiploic artery; and (c.) a terminal plexus, which follow the arteries in their divisions in the spleen, even to their smallest branches.

With these there are few, if any, ganglion cells. On the splenic plexus there are, in man, a few Pacinian corpuscles, especially along the back of the pancreas.

The branches from the convexity of the coeliac plexus are fourfold.

4. The **mesenteric plexus** is a large, single off-shoot from the under border plexus accompanying the superior mesenteric artery. The ultimate branchings are threefold—(a.) inferior pancreatico-duodenal; (b.) colic, to the transverse and ascending colon; and (c.) intestinal, which form networks in the mesentery, dividing on the intestine into two series—one whose fibres pierce into the muscular coat forming the **plexus of Auerbach** (p. 404), and the other accompanying the vessels closely into the submucous tissue, and forming therein the **plexus of Meissner**. For the supply of the vessels, of the muscularis mucosæ, and of the glands, branches pass from this plexus to the villi, in which they end in two series, superficial and deep.

5. The **phrenic plexus** is a paired, but unsymmetrical set of nerves. The right chiefly arises from the right semilunar ganglia, accompanies the right phrenic artery, and is joined by a branch of the right phrenic artery, a small **phrenic ganglion** marking the point of junction. The left is smaller, has no ganglion, and seldom has a large junction with the left phrenic nerves, although there are always unions of small filaments detectible.

6. The **suprarenal plexus**. About 30 parallel white fibres pass into each suprarenal body arising from a long space of the circumference of the ganglion. They are almost all medullated and distinct; most of them do not accompany the arteries. Their endings are unknown, but there are many ganglion cells in each body.

7. The **renal plexus** is a large off-set from the semilunar ganglion, directed downwards and outwards towards the renal artery. It is joined by the lesser and least splanchnic nerves (p. 352), and enlarges into an irregular ganglion, the **aortico-renal ganglion**, which lies above and internal to the renal artery and sends off a large number of branches which stream over the root of the renal artery, join descending lateral branches from the coeliac plexus and from the upper part of the aortic plexus. The renal branches, which are numerous, gelatinous, and grey, with many ganglion cells, enter the kidney at the hilum and end on the vessels in the kidney.

Two offshoots pass down from the renal plexus—one, the **ureteric**, descends behind the renal artery and forms a plexus with ganglion cells in its meshes in the coats of the ureter; the second, the **spermatic plexus**, descends from behind the renal to the spermatic artery and accompanies that vessel to the testis in the male, to the ovary in the female; the former plexus sends off vascular, epididymal, and glandular branches; the latter, ovarian, tubal, and uterine.

The Lumbo-sacral Chain of Ganglia.—The cord of the sympathetic, descending from the twelfth dorsal ganglion, passes through a fissure, close to the inner border of the inner arcuate ligament, and joins a first lumbar ganglion on the first lumbar vertebra. There are usually four small elongated ganglia (sometimes five) lying on the vertebral bodies internal to the *psaos*, and joined by long rami communicantes to their nerves. The last lumbar ganglion is behind the common iliac arteries, and from it the sympathetic cord descends on the front of the sacrum, internal to the sacral foramina, and there makes four ganglia. These sacral cords of the two sides approximate as they descend, and the inferior cord of the last joins its neighbour in a small central coccygeal ganglion (**ganglion impar**) in about 60 per cent. of cases.

From these ganglia there pass off—(1) internal branches to the aortic plexus, arising from the three upper lumbar ganglia. These join the branches descending from the renal and coeliac plexuses, and along each side of the aorta make a thick plexus, interwoven especially on the left with lumbar lymphatics, and

sending off branches to the aorta and its parietal branches, and on the left side a large **inferior mesenteric plexus**, in which, beneath the artery, there is usually an irregularly elongated **inferior mesenteric ganglion**. The branches of this plexus supply the large intestine below the splenic flexure.

At the bifurcation of the aorta the aortic plexuses of each side are united medially in front of the aorta, the lateral branches streaming downwards and inwards across the common iliac arteries. These unite in front of the lower part of the aorta, and below it on the promontory of the sacrum, to form a **hypogastric plexus**. This begins about 1 cm. below the inferior mesenteric artery, and it is joined, as it descends, by branches from the last lumbar and sacral ganglia. It sends off vasomotor nerves to the iliac arteries, a small central plexus around the middle sacral, and divides below into two lateral closely-woven plexiform bands, the inferior hypogastric plexuses, from which arise—(1) the rectal plexus to the wall of that gut, along the rectal arteries; (2) the inferior ureteric, arising high up from this plexus, and sending ascending and descending branches on this tube; (3) the vesical plexus, which accompanies the vesical arteries, consisting of fibres chiefly from the third and fourth sacral nerves. These nerves form a large plexus in the muscular coat of the bladder, and send numerous filaments to the mucosa, especially that of the trigone.

4. The deferentio-prostatic plexus passes forwards between the rectum and the bladder, and divides into numerous branches; one of these ascends on the vas deferens to the deep abdominal ring, communicating with the spermatic plexus there, others descend to the walls of the seminal vesicles and to the prostate. The filaments to the latter organ occasionally unite in a **prostatic ganglion** behind the edge of the *levator ani*. The branches of this series usually come from the third and fourth sacral nerves.

The front of the plexus prostaticus is continued along the corpora cavernosa as the plexus cavernosus, and contains the nervi erigentes from the second sacral. The plexus on each side divides into two; a cavernous, the smaller, to the corpora cavernosa, and a urethral to the corpus spongiosum, the latter being the larger. The nervi ejaculantes arise probably on a higher level.

In the female there are two utero-vaginal plexuses, an anterior and a posterior, in the walls of the uterus, forming minute ganglia in the substance of the organ; one of these is large, and placed on the neck of the uterus, forming the cervical uterine ganglion. The uterine nerves increase in size and number during pregnancy. The nervi parturientes probably arise from branches of the upper lumbar nerves. The exact limitation of these special groups of nerves in the human nervous system has, however, not been defined with precision.

Dissection.—Remove the peritoneum and areolar tissue from the inferior surface of the *diaphragm*, leaving the vessels and nerves on the muscle. If the thorax have been dissected, remove the pleura from the upper surface of the *diaphragm*.

The diaphragm (fig. 581, 3) is the partition between the abdomen and the thorax, and consists of two parts, a central tendon and a circumferential muscular part. The latter arises by fleshy or short tendinous fibres—(a.) from the hinder surface of the metasternum (fig. 421, 7); (b.) from the lower half of the cartilage of the seventh rib, and from the entire lower borders of the cartilages of all the false ribs (*ib.*, 8); (c.) from the upper surface of a strengthened fibrous band of the fascia covering the *quadratus lumborum*. When this band is detached from the weaker lower part of the fascia it appears as an arch, and so is called **ligamentum arcuatum externum**. When thus separated the arch is attached to the twelfth rib, and to the costal process of the first lumbar vertebra. (d.) Fibres also arise from the upper surface of a similar arch formed by a strengthened area of the fascia covering the psoas (**ligamentum**

arcuatum internum). This arch passes from the costal process of the first lumbar to the body of the second lumbar vertebra. (*e.*) Two unsymmetrical origins spring from the bodies of the lumbar vertebræ. These are called the two crura. The right crus arises tendinously from the anterior surface of the three upper lumbar vertebræ, the left from the two upper, and both are inseparably connected with the anterior common vertebral ligament.

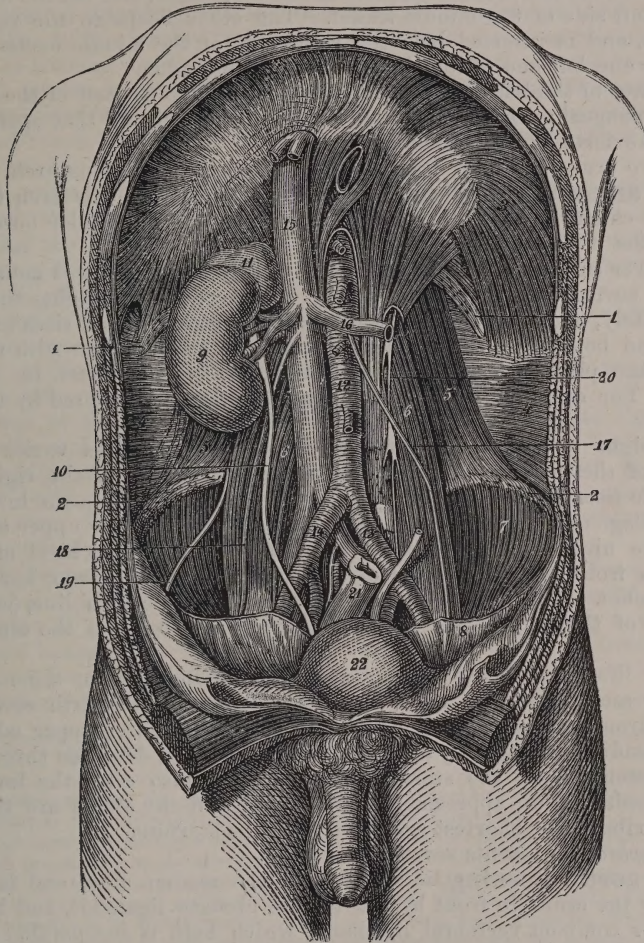


Fig. 581.—Deep muscles of abdomen—1, twelfth rib; 2, iliac crest; 3, diaphragm; 4, transversalis; 5, quadratus lumborum; 6, psoas magnus; 7, iliacus; 8, peritoneum; 9, right kidney; 10, ureter; 11, suprarenal capsule; 12, aorta; 13, right common iliac; 14, left ditto; 15, inferior vena cava; 16, left renal vein; 17 and 18, spermatic veins; 19, external cutaneous nerve; 20, sympathetic; 21, rectum; 22, bladder.

From all these origins the fibres pass inwards to be inserted into the circumferential margin of the central or cordiform tendon. This is a strong, thin, glistening tendon, whose fibres cross in various ways, and it is divisible into three lobes or leaflets; of these the middle underlies the heart, the right or largest leaflet lies to the right, and the left or smallest to the left side.

The middle leaflet receives the two lateral metasternal bands, which are separated by a median linear interval. It also receives the fibres from the cartilages of the seventh and eighth ribs, from the last especially on the left side. The fibres from the other ribs and from the ligamenta arcuata pass into the peripheral edges of the right and left leaflets. The fibres of the right crus ascend to the right of the aorta, and then divide into two bundles, one of which passes in front of the aorta to the left of the œsophagus, and is inserted into the back and left side of the middle leaflet. The other keeps to the right of the œsophagus, and is inserted into the right side of the middle leaflet, and into the hinder and left end of the right leaflet of the tendon.

The fibres of the left crus pass for the most part to the left of the aortic and of the œsophageal openings, but a few pass to the right of that opening, lying between the aorta and the œsophagus.

The two crura are united across the aorta by a tendinous arch, the **ligamentum arcuatum medium**. From the convexity of this arch fibres arise which pass chiefly to the right of the œsophagus and the hinder border of the middle leaflet of the tendon.

The lower surface of the *diaphragm* is deeply convex, and is moulded upon the upper surface of the viscera, chiefly the liver to the right, the stomach intermediately, and the spleen to the left. The right portion rises higher than the left, and both than the middle portion. In close contact with the middle leaflet is the pericardium, enclosing the heart, which causes its slight depression. The other portions of the upper surface are covered by the pleuræ and lungs.

The height to which the dome of the *diaphragm* rises varies with the condition of the organs; in general, after death the top of the right portion of the dome rises to the level of a horizontal line drawn from the lower border of the cartilage of the fourth rib in the parasternal line to the upper edge of the body of the ninth dorsal vertebra; the left portion to the level of a similar line drawn from the upper edge of the fifth rib to the lower border of the ninth vertebra. The middle portion lies on the plane of a line, joining the upper part of the back of the metasternum and the body of the tenth dorsal vertebra.

During life these levels are changed during inspiration, the right dome being depressed to the plane of the lower border of the fifth cartilage, descending through nearly 2 cm., and the left to that of the upper edge of the sixth, descending through 2.5 cm. The middle portion descends through about 1 cm. Distension of the stomach or colon can also alter the level of the muscle, pressing it up appreciably. The longest fleshy fibres are those from the eighth ribs. The shortest are those from the sternum.

The *diaphragm* presents several openings—

1. The **aortic opening** is situated in the median line, and is bounded laterally by the crura, in front by the middle arcuate ligament, and behind by the anterior common vertebral ligament, which here is inseparable from the edge of the left crus. Through this opening passes the aorta, with the vena azygos to its right, and the thoracic duct between these vessels. The opening is on the level of the twelfth dorsal vertebra, and its level and dimensions are unaltered during the action of the muscle.

2. The **œsophageal opening** is an oval hole, bounded on each side by the fleshy fasciculi passing from the crura to the central tendon, the left fascicle of the right crus lying to its left side, and the fibres arising from the middle arcuate ligament lying to its right. When all the surrounding connective tissues are removed this opening appears as a lanceolate slit. Through it pass the œsophagus and the two vagus nerves, together with descending œsophageal branches of the thoracic aorta, which anastomose with œsophageal branches of the

gastric artery. This opening lies in front and a little to the left of the aortic ; it is on the level of the tenth dorsal vertebra, and may be displaced upwards or downwards through about 1 cm. between the extreme positions of the *diaphragm*. Being muscular, it may vary in diameter and, when contracted, its margins constrict the œsophagus, which is only united to the borders of the opening by lax areolar tissue.

3. The **caval opening**, on the other hand, is an aperture with a tendinous border, which is inseparably tied to the adventitious coat of the inferior vena cava. It is a round opening placed between the right and middle leaflets of the central tendon, nearly at the highest level of the *diaphragm*, opposite the ninth dorsal vertebra. It is on a plane anterior to the others, and varies a little (about 6 mm.) in level with respiration. Besides these three large openings there are the following smaller perforations :—

4. The **costo-xiphoid space** on each side is situated between the metasternal and the seventh costal slip. This is a very small triangular slit transmitting the superior epigastric branch of the internal mammary artery, and the ascending lymphatics from the abdominal wall, which here enter the anterior mediastinum.

5. The **openings for the great splanchnic nerves** are tubular perforations in the crura, one on each side.

6. The **opening for the hemiazygous vein** ascends through the outer edge of the left crus.

Posterior to the *diaphragm* and behind the inner arcuate ligament, the *psoas* muscle and the cord of the sympathetic descend, sometimes the latter passes through an independent opening, and may have with it the lesser splanchnic nerve, otherwise this nerve passes through a separate tunnel in the crus. Beneath the outer arcuate ligament the *quadratus lumborum* and the subcostal nerve descend.

The *diaphragm* is supplied by the phrenic nerve, mainly from the fourth cervical, small filaments pass into it from the five lower intercostal nerves and from the phrenic ganglion of the sympathetic. Its blood supply is chiefly from the phrenic branches of the abdominal aorta and the phrenic branches of the internal mammary, supplemented by small branches from the five lower intercostal arteries.

The *diaphragm* enlarges the thorax in inspiration partly by the small descent of the flat tendinous areas, but chiefly by the rectification of the curves of its fleshy fascicles. These not only thus enlarge the costo-phrenic interspace, but acting from the central tendon which is forcibly pressed against the but-little-compressible abdominal viscera, they also serve to elevate the lower ribs and so to expand the inferior aperture of the thorax.

The *diaphragm* is primarily a ventro-mesodæal muscle developed in the plane of embryonic tissue which invests the mesodæum and which lies behind the heart. This plane of tissue, a derivative of the septum transversum, contains in it the great venous trunks passing to the auricle, the ducts of Cuvier, and in its lower surface the liver is developed. When muscular tissue first appears in it, it has become altered in position, but, primarily, when the heart is placed below the visceral arches, and when the lungs are first apparent as saccular outgrowths from the cervical end of the mesodæum, it is placed near the cervical flexure.

With the descent of the heart and the downward expansion of the lungs the septum transversum is forced downwards, and when, at an early period, muscular tissue develops in it, this is also carried downwards, causing its nerve, which originally passed forwards in front of the great vessels, to become elongated downwards. In its descent it extends from before backwards on each side until it occupies the inner face of all the bones which bound the lower boundary of the thorax. As the modification of the great venous confluence of the saccus venosus (p. 81) carries thoraxwards a portion of the septum transversum, the connective tissues below the saccus become firmly organised into a tendinous plane, which thus fills the gap caused by this upward displacement and constitutes the central tendon. A trace of its primitive cervical origin survives in the persistence of its cervical innervation. The latest portion to develop is consequently the vertebral portion, and the aortic opening is the remains of the original post-diaphragmatic space.

The average male adult *diaphragm* weighs 150 grammes and is 147·8 c.cm. in volume.

It presents on its abdominal side a surface of a little over 1000 sq. cm., being the one-fifth part of the surface of the collective mass of the abdominal viscera.

Quadratus lumborum (fig. 581, 5) lies external to the *psaos*, and directly in front of the lateral intermuscular septum; it consists of two sets of fibres, one series arising from the ilio-lumbar ligament and the iliac crest for 5 cm. immediately above and internal to the oblique gluteal line, these fibres are inserted into the lower edge of the last rib and into the costal processes of the four upper lumbar vertebræ. The second or deeper set of fibres arise from the iliac crest behind the last, and are inserted into the costal processes of the three upper lumbar vertebræ. This muscle is covered by an aponeurosis homologous with the endothoracic and transversalis fasciæ, and lies on the lateral intermuscular septum (p. 71). It is a specialised portion of the intercostal system of muscles, to which at the lower portion of the thorax it has the same relation that the *scaleni* have at the cervical end. It is supplied by small metameric branches of the three upper lumbar nerves. The kidney lies on its anterior surface, to which the outer border of this muscle serves as a guide.

Dissection.—The *psaos* muscle (§ 360) having been examined conjointly by the dissectors of the leg and abdomen, the branches of the lumbar plexus, which appear at the outer border of that muscle, are to be traced backwards into the substance of the *psaos*, the anterior part of which should be cut away; carefully preserving as nearly as possible in its normal place the genito-crural nerve, which descends on the front of that muscle, having emerged at its inner border. These nerves are now to be followed downwards as far as they lie in the abdominal cavity.

The lumbar plexus (fig. 582) is formed by the union by cross communications, of the ventral trunks of the four upper lumbar nerves. It lies in the *psaos* muscle and on a plane anterior to the costal processes of the lumbar vertebræ.

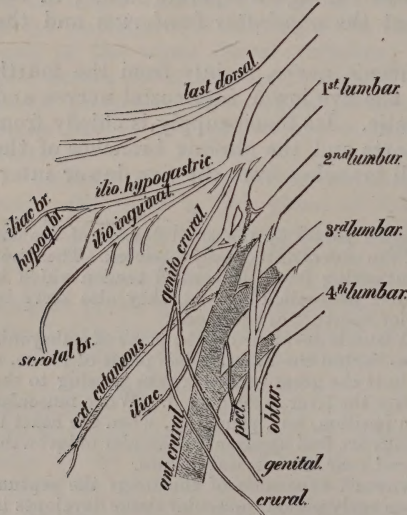


Fig. 582.—Diagram of the lumbar plexus; the posterior divisions are shaded, the anterior left clear.

The first lumbar trunk receives a small twig from the subcostal, and divides into four branches:—(1) A small metameric branch to the *quadratus lumborum*; (2) a large cutaneous outgoing branch, which, after a short course, bifurcates into the *ilio-hypogastric* and *ilio-inguinal* nerves; (3) a communicating branch to the second lumbar; (4) a small internal branch, which passes downwards and forwards on the inner side of the *psaos* muscle to join a branch from the common cord made by the junction of the last-named branch with the second lumbar, giving origin to the *genito-crural* nerve.

The second, third, and fourth lumbar ventral trunks, having given off metameric branches to the *quadratus lumborum*, divide into anterior and posterior divisions. The anterior division of the second sends off the branch just named to the *genito-crural*, and then descends on the inner side of the *psaos* to unite successively with the anterior division of the third and fourth lumbar nerves; the cord thus formed being the *obturator* nerve. The posterior division of the second divides into two—one small branch joins a small branch of the posterior division of the third and forms the external cutaneous, while

the larger branch joins the larger branch of the posterior division of the third and the whole of the posterior division of the fourth, and form the largest branch of the plexus, the **anterior crural**. A descending branch of the fourth, not shown in the diagram, descends to unite with the fifth lumbar, which joins the first sacral nerve, and forms with it the lumbo-sacral cord.

The **ilio-hypogastric** and the last dorsal nerve are reciprocal in point of development; when one is large, the other is small or absent. The ilio-hypogastric appears at the outer border of the *psaos*, and passes obliquely beneath the fascia and upon the front of the *quadratus lumborum* muscle posterior to the kidney. It pierces the *transversalis* muscle as it crosses the downward continuation of the posterior axillary line, and lies for a short distance between that muscle and the *internal oblique*; here it gives off a lateral cutaneous (iliac) branch, which pierces the two *oblique* muscles and descends over the iliac crest at about its anterior point of trisection, supplying the skin in front of the upper edge of the *gluteus maximus* (fig. 586, *b*). The continued or anterior cutaneous trunk (hypogastric branch) passes forwards beneath the *internal oblique*, which it pierces close to the linea semilunaris, and passing through a hole in the *external oblique* tendon it supplies the skin of the front of the abdomen from the umbilicus down to the pubes.

The **ilio-inguinal** nerve is also a purely sensory nerve, and is usually smaller than the last, with which, however, it is in about eighteen per cent. of bodies combined. It descends across the lower border of the *quadratus lumborum* with a greater degree of obliquity than the last, and reaches the *transversalis* muscle close to the iliac crest; here it successively pierces this muscle and the *internal oblique*, finally piercing the *external oblique* close to the outer border of the superficial abdominal ring, or else it may traverse the ring, and is distributed to the skin of the outer surface of the scrotum or labium and of the opposed area of the thigh.

The **genito-crural** nerve is a compound trunk which is often divided into two parts for its whole extent. It is formed by filaments of the first and second lumbar nerves, and escapes between the *psaos* muscle and the vertebral column, descending thence on the front of the *psaos* beneath the peritoneum and ureter. It usually divides here into its two parts—the crural and the genital branches. The genital branch descends obliquely across the external iliac artery lying on the subperitoneal tissue (Abernethy's fascia), and passes into the substance of the spermatic cord as it is being constituted at the deep abdominal ring. It passes on the cord through the rings and inguinal canal, and breaks up into branches on the *cremaster* muscle, which it supplies.

The crural branch (fig. 589) is sensory, and descends along the inner edge of the *psaos* to pierce the fascia beneath Poupart's ligament; it usually pierces the ilio-pectineal ligament (fig. 261), but may pass through the lacuna musculosa, more rarely through the vascular lacuna, external to the femoral vessels. Not uncommonly it unites with the middle cutaneous branch of the anterior crural nerve before piercing the fascia, to be distributed to the skin of the thigh.

The **external cutaneous nerve** (fig. 581, 19) can be seen descending across the *iliacus* muscle to the superior iliac notch, through which it escapes. It is the earliest branch of the anterior crural system of nerves (§ 335).

The **anterior crural** descends in the interspace between the *psaos* and the *iliacus* to pass through the lacuna musculosa beneath the crural arch; before escaping it gives off three branches to the *iliacus* muscle. Not uncommonly it gives off also within the pelvis a superior internal cutaneous branch. This often arises along with the nerve to the *pectineus*, and when this is the case it lies along the inner surface of the *psaos* muscle, and the combined trunk passes through the lacuna vasculosa behind the femoral vessels, then dividing into its pectineal branch to the *pectineus* muscle and its cutaneous branch. When this

conjoint stem is present it is sometimes erroneously called accessory obturator nerve, but it has nothing whatever to do with that nerve, as it is really one of the extensor (posterior) series of nerves (§ 351); for the remaining course of the anterior crural, see § 346.

The **obturator** nerve is the chief anterior branch of the plexus. It descends between the *psaos* and the vertebral column lying upon the ilio-lumbar artery which separates it from the lumbo-sacral nerve, and behind the iliac vessels. Dipping into the pelvis it appears in the angle of divergence of the internal and external iliac arteries, along the lateral wall of the pelvis, internal to the pelvic fascia, which it pierces at the obturator foramen. It escapes through this opening above the obturator artery (except when that vessel arises from the epigastric). Its subsequent course is traced in § 355.

THE LOWER EXTREMITY.

315. The lower limbs are the organs of support and progression, and are, therefore, stronger in framework and in muscles, and provided with larger vessels and nerves than the upper limbs, while the ranges of motion of their several joints are smaller and the pelvic girdle is fixed to the vertebral axis. Each limb is on an average about 0·22 of the weight of the body; the left being usually a little the heavier and stronger. The length of these limbs is the most variable part of the stature. In development the lower limbs have undergone a preaxial and ventral rotation, and the foot is permanently pronated.

Superficial Landmarks.—The surface markings to be observed before dissection in the region of the buttock are the iliac crest and spines, the tuber ischii, and the great trochanter. From the lower end of the vertebral column the median post-anal groove is continued forwards between the nates and thighs into the perineum. The prominence of the nates on each side of this is correlated with the upright position, and is peculiar to man. The horizontal **sulcus of the nates**, which separates the prominent **fold of the nates** (fig. 583, +) above from the back of the thigh below, is an extension fold, and disappears on flexion; hence in hip-joint disease, when the patient always keeps the hip slightly flexed, this fold becomes obliterated as a result of the flexion, not of the wasting of the muscles, which does not take place until later. The upper point of trisection of a line joining the posterior iliac spine and the mid-point between the tuber ischii and great trochanter, indicates the point of emergence of the gluteal artery. The middle of a similar line from the posterior iliac spine to the inner point of trisection of the line between tuber and trochanter shows the spot where the sciatic artery leaves the pelvis. These guides are known as **Lizars' lines**. On the front of the thigh the superior iliac spine and the pubic spine and crest are to be noticed, and the fold of the groin, or the line of Poupart's ligament, extending between them. The structures along this line are relaxed by flexion, adduction, and rotation inwards, but made tense by the opposite motions. There is usually a sulcus below the fold of the groin, starting from the femoro-scrotal furrow and dying away midway between the great trochanter and the superior iliac spine. This, which is called **Holden's line**, crosses the middle of the capsule of the hip. Below the pubic spine the prominent inner ridge of the adductor muscles is palpable, and

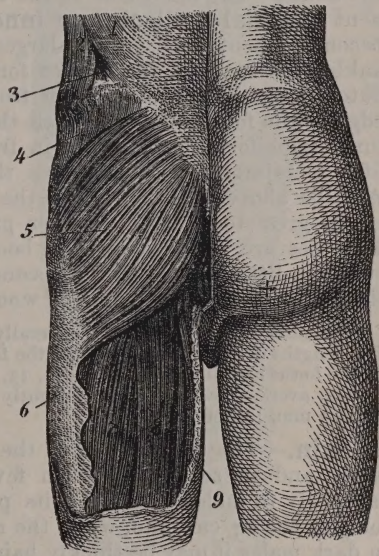


Fig. 583.—Gluteus maximus dissected on the left side, right buttock undissected, showing fold marked + :—1, latissimus dorsi; 2, external oblique; 3, Petit's triangle; 4, gluteal fascia; 5, gluteus maximus; 6, fascia lata; 7, biceps; 8, semitendinosus.

if the hip be forcibly extended, the fascia lata feels tense along its outer side from the iliac crest to the external tuberosity of the tibia. A line joining the superior spine and the tuber ischii passes across the middle of the acetabulum and over the top of the trochanter. This is called **Nelaton's line**.

The course of the femoral artery is represented by a line drawn from the middle point of the interval between the superior iliac spine and the symphysis pubis to the inner side of the inner condyle of the femur. At the knee the patella and the femoral condyles are prominent above the joint; the tubercle, outer tuberosity, and inner edge of the head of the tibia and the styloid process of the fibula project below. Above and behind the last point the tendon of the *biceps* can be felt, while on the inner side of the back of the knee the tendons of *semitendinosus* and *semimembranosus* are prominent. The hollow space between these outer and inner tendons at the back of the knee is the **popliteal space**.

Along the front of the leg the shin, or crest of the tibia, is palpable, separating the subcutaneous inner area of the tibia from the region of the *digital extensors*, which lies external to it. Posteriorly is the thick muscular swelling of the calf of the leg, tapering below to the narrow supramalleolar region above the ankle. The inner side of the tibia is continued downwards into the prominent **internal malleolus**, or **inner ankle**, while on the outer side the fibula becomes subcutaneous, and enlarges into the **outer malleolus**. Of these two ankles the inner is the farther forward and is covered by a tensor skin; the outer is the lower down. In front of the inner ankle and along the inner edge of the foot there can be felt the tubercle of the scaphoid and that of the inner cuneiform bone, while in front of the outer ankle is the spur of the fifth metatarsal. Posteriorly is the prominence of the heel, with the tendo Achillis above it, and below is the plantar region, ending in front in the ball of the great toe, and the smaller prominences over the outer metatarsal heads. The toes are rarely straight in boot-wearing races; the great toe is generally curved a little outwards, the second usually bent so that its tip falls short of the end of the hallux, which it would exceed if the toe were extended.

The embryonic lower limb is generally flexed, and the embryonic foot is always inverted. The lengths of the toes in mm. in the fifth-month fetus average respectively 6, 5, 4, 4, 4. In the fetus at full term they are 13, 13, 10, 9, 9.

The average lower limbs are slightly unequal, the left being, in 62 per cent. of limbs, about 3 mm. longer.

Skin.—The integument of the buttock is moderately thick, low in vascularity and in sensibility, with few papillæ and a coarsely wrinkled surface, especially in males and along its prominent fold. Its sweat glands are about forty to the sq. cm., and, while the region is generally bare of conspicuous hairs, in dark males it may be thickly hairclad, especially towards the middle line, the hairs converging to the post-anal groove. Skin of a similar character clothes the back of the thigh, but in front, at the hollow of the groin, it is thin, smooth, elastic, with thin cuticle, small papillæ, and few hairs except towards the pubes. Lower down, especially towards the outside of the thigh, the hairs are more numerous (eight to the sq. cm.), directed outwards and a little upwards at their bases, and accompanied by large sebaceous glands. The sweat glands are also large (about seventy-four to the sq. cm.).

The skin is loose about the front of the knee, its epidermis being thickened on the patella and tibial tubercle; it is thinner and more naked on the popliteal space. The corium is fastened by radiating fibres to the inner and back part of the tibia and to the head of the fibula. The hairs on the leg, especially on the inner surface, are larger than those on the thigh, and are directed downwards and inwards. The skin of the dorsal surface of the foot is thin and loosely attached, with few or no hairs, and many small sweat glands (122 to the sq. cm.).

cm.). Around the margins of the foot the skin is attached by radial bands, hence it appears somewhat folded or wrinkled. Over and behind the ankles and above the heel the skin is also thin, soft, and loosely attached. On the sole of the foot it is bare of hair or sebaceous glands, and presents peculiarities on the heel, on the ball of the hallux, on the outer side, and in the hollow of the arch. On the heel is the thickest epidermis in the body, marked by transverse ridges, corresponding to the ridges of the large dermal papillæ. On the ball of the hallux it is also thick, with concentric papillary ridges. In the hollow of the arch it is softer, not so closely attached, but marked by many wrinkles, which tend to pass forwards and towards the first or second interspaces. On the outer side there is a long area of thick adherent skin stretching from the heel by the spur of the fifth metatarsal, to expand into a continuous welt, with transverse papillary ridges which curve forwards at each side, beneath the heads of the outer metatarsals. A transverse sulcus bounds this pad in front, and marks off the toes from the sole.

The skin of the toes is peculiar, in that the nail matrices are rarely crescentic, and the lunula is almost always covered by the nail fold. Patches of papillæ are liable to hypertrophy between the toes, and the patches of epidermis which cover them to become horny and thickened, constituting corns. The plantar sweat glands are large (350 to the sq. cm.).

316. GLUTEAL REGION.—The body is to be placed back upwards on the table, with a block under the loins, and the skin to be divided (1) along the middle line from the fourth lumbar spine to the tip of the coccyx; (2) from the upper end of this incision outwards along the crest of the ilium to the superior spine; and (3) from the lower end of the first incision along the lower border of the tuber ischii, and thence downwards and outwards to the outer side of the thigh 16 cm. below the great trochanter. Reflect outward this flap, exposing the underlying thick layer of fatty superficial fascia, to whose surface the deep layer of the cutis is tied by many fibrous processes, especially along the fold of the nates, hence the pain in furuncular inflammations, which are not uncommon in this region. The skin is also tied to the great trochanter by radiating bands. A small subcutaneous bursa usually overlies the prominent portion of the sacrum, especially in thin males, and the superficial fascia becomes fibrous

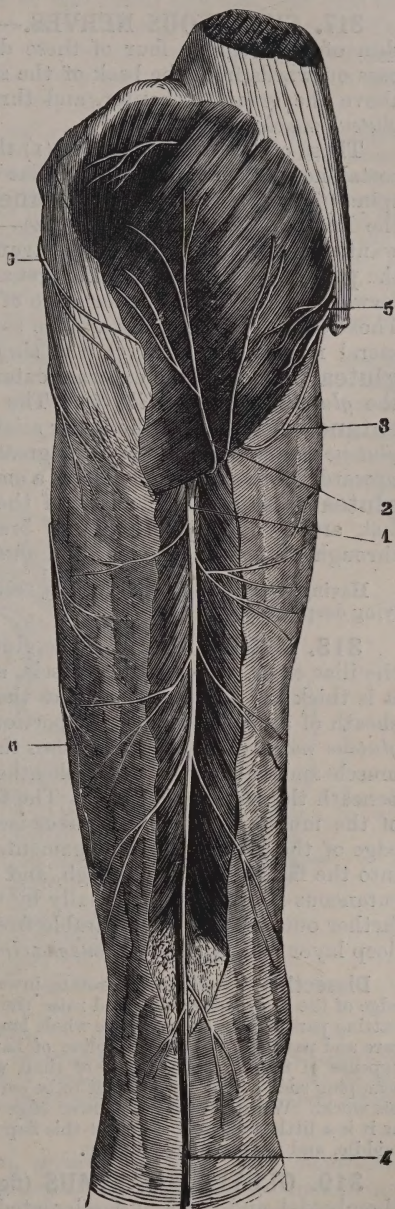


Fig. 584.—Cutaneous nerves of the gluteal region and back of the thigh.

and tough over the tuberosity of the ischium. In females, especially those of short stature, the fatty superficial layer is thicker than in males, and in some African races, is much thicker than in Europeans (steatopygia).

317. CUTANEOUS NERVES.—Ten nerves pass through this fascia to the skin of this region; four of these descend across the crest of the ilium, two pass outwards from the back of the sacrum, one passes backwards and inwards above the great trochanter, and three ascend round the lower border of the *gluteus maximus*.

Those of the first series are (1) the **lateral cutaneous** branch of the subcostal nerve, which crosses the iliac crest about 5 cm. behind the superior iliac spine (fig. 353); (2) **lateral cutaneous** branch of the ilio-hypogastric behind the last and its reciprocal in size—occasionally the one or other of these is wanting or united into a single trunk; (3 and 4) the **external branches** of the **posterior division** of the first and second lumbar nerves descend obliquely forwards near to the upper edge of the *gluteus maximus* muscle (*ib.*, *Ext.* 1). Those of the second series are the two **posterior cutaneous** branches of the sacral nerves (fig. 584, 5), the single nerve which passes backwards is the **gluteal** branch of the external cutaneous which descends over the insertion of the *gluteus maximus* (*ib.*, 6). The ascending nerves are (1) the **recurrent cutaneous** branch of the lesser sciatic, which emerges at the lower edge of the *gluteus maximus* between the great trochanter and tuber ischii, and turns upwards to the skin (*ib.*, 2); (2) a small **cutaneous branch of the inferior gluteal** usually independent of the last, shown in the figure internal to the last, and (3) the **perforating** branch of the fourth sacral which emerges through the sciatic ligament and *gluteus maximus* (fig. 587, 6).

Having dissected out these nerves, remove the intervening fat which covers the underlying deep fascia.

318. DEEP FASCIA.—The gluteal portion of the fascia lata is attached to the iliac crest, to the lumbar fascia, and to the back of the sacrum. Anteriorly it is thick and white as it overlies the *gluteus medius*, being here the degenerated sheath of an obsolete anterior portion of the muscle. At the upper edge of the *gluteus maximus* it splits into two thin layers, a superficial, which overlies the muscle and sends processes to sheathe its fascicles, and a deep layer which passes beneath the *gluteus maximus*. The former is continued round the lower border of the muscle between the tuber ischii and the coccyx, and is attached to the edge of the greater sciatic ligament. Outside the tuber ischii it is continuous into the fascia lata of the thigh, and is here pierced externally by the recurrent cutaneous nerves, and internally by the long pudendal nerve (fig. 584, 3). Still farther outwards it is inseparable from the tendon of the *gluteus maximus*. The deep layer beneath the *gluteus maximus* forms the sheath of the *gluteus medius*.

Dissection.—Adduct and rotate inwards the leg. Divide the fascia along the upper edge of the *gluteus maximus*, and raise the layer covering the muscle as a continuous sheet, cutting parallel to, and along the whole length of, the fleshy fascicles. This dissection craves care and patience, but the discipline of hand acquired in making it is cheaply bought at the expense of the necessary outlay of time, while the slovenly habit, too readily acquired by scamping such a dissection, is apt to be carried by the student into the other departments of his work. When cleaning the lower edge of the muscle abduct the thigh. On a left limb, as it is a little awkward to reflect this flap from above, it is better to divide the fascia in the middle, and to reflect it each way.

319. GLUTEUS MAXIMUS (fig. 583, 5), the largest muscle in the body, rhomboidal and coarsely fasciculated, arises by short tendinous fibres from the fascia which invests it anteriorly, from the posterior gluteal line of the ilium (p. 164) and the rough posterior gluteal surface behind it, from the lumbar fascia behind the iliac crest, from the backs of the third and fourth sacral vertebrae, from the side of the coccyx, and from the inner portion of the great

sciatic ligament. Its fascicles, which are nearly parallel, run outwards and downwards, to be inserted into the fascia lata on the outer part of the thigh, into the surface of the tendinous sheath of the *vastus externus*, and into the rough gluteal line on the femur below the root of the great trochanter. The upper half of the muscle, including nearly all its iliac origin, is inserted into the fascia lata, and is often bilaminar. The lower part of the insertion is also in two layers, a superficial or fascial, and a deep or bony.

It is supplied by the inferior gluteal nerve (1 and 2 s.), and it is nourished by the superficial branch of the gluteal artery and the gluteal branch of the sciatic. This muscle abducts the thigh and rotates it outwards, and makes tense the fascia lata. In walking, it acts from thigh to pelvis, extending the hip-joint and maintaining the upright position. Its upper edge is tied down by the investing fascia, its lower thick edge forms, with the overlying fat, the prominence of the buttock (p. 469). The predominance of this muscle is essentially a human character; it forms 19 per cent. of the musculature around the hip-joint in man; 13 per cent. in the gorilla; 12.5 per cent. in the chimpanzee, and 12 per cent. in the orang. Its coccygeal part represents the separate *caudo-femoral* muscle of other mammals. This muscle is a segmentation of the superficial posterior sheet of limb muscles representing in part the *scapular deltoid*, in part the *latissimus dorsi* of the upper limb.

Dissection.—Having rendered definite the upper and lower edges of this muscle, divide it along a line drawn from the middle of the iliac crest to the tuber ischii, and reflect each part, clean the vessels and nerves which are attached to the deep surface of the muscle.

The parts exposed on raising it are the *gluteus medius* and its investing fascia, occasionally a strip of the *gluteus minimus*, the superficial gluteal artery, the *pyriformis* muscle, the sciatic and pudic vessels and nerves, the *gemellus*

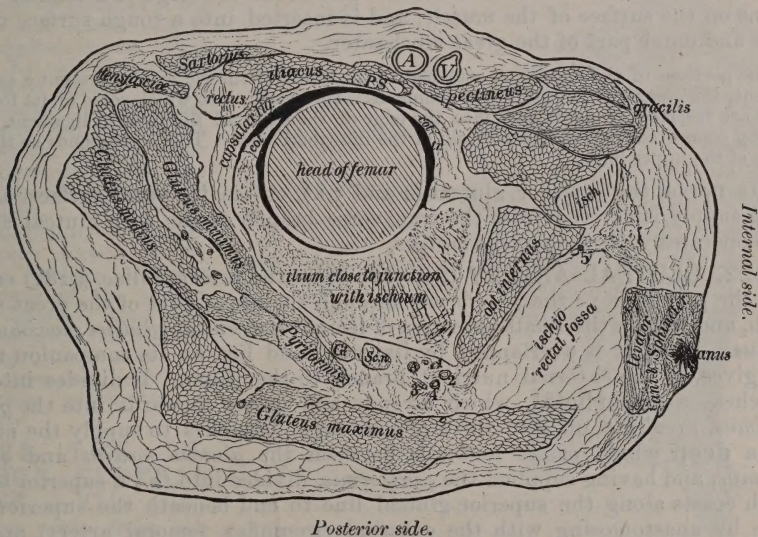


Fig. 585.—Oblique section through the hip-joint, showing the relations of the muscles and the parts covered by the gluteus maximus—A, V, femoral artery and vein; Gt. Sc. n., great sciatic nerve; 1, 2, pudic vessels; 3, small sciatic nerve; 4, 4, sciatic artery and its coccygeal branch.

superior muscle, *obturator internus* tendon, *gemellus inferior*, and *quadratus femoris*, the greater sciatic ligament, tuber ischii, the origin of the hamstring muscles, the great trochanter, the upper edge of the *adductor magnus*, the crucial anastomosis, the upper part of the *vastus externus*, and usually three bursæ—one, large, over the great trochanter, a second, often communicating with the former, between the laminae of the tendon, over the *vastus externus*, and a third, somewhat variable, over the tuber ischii, present in 45 per cent. of limbs.

Dissection.—Clean these parts, and remove the fascia which covers the *gluteus medius*, stretching the muscle by adduction and rotation inwards while dissecting the hinder fibres, and by rotation outwards while dissecting the foremost.

320. GLUTEUS MEDIUS, thick and triangular, arises from the middle gluteal area of the ilium, and from the fascia which covers it. It is inserted by a flat tendon into the broad line which crosses the great trochanter from its tip downwards, outwards, and forwards. Acting from the ilium it is an abductor of the thigh, and by its anterior fibres a rotator inwards; acting from the femur it extends and draws outwards the pelvis. Its tendon begins between two planes of fleshy fibres. The muscle is supplied by the horizontal branch of the superior gluteal nerve (5 l. and 1 s.) and is nourished by the ascending branch of the deep gluteal artery; a small bursa underlies its tendon.

An **ilio-trochanteric tendinous band** is attached to the superior iliac spine at its anterior border, and ends in the sheath of the *gluteus minimus* and capsule of the hip-joint. From it some of the anterior fibres of the *gluteus medius* arise, and this renders the separation of the two glutei at their anterior inferior margin a task of some difficulty. This muscle is the serial homologue of a part of the *infraspinatus* in the upper limb.

Dissection.—Divide the tendon of the *gluteus medius* and reflect the muscle upwards, leaving it still attached by its origin. Clean the vessels and nerves which lie on its lower surface and on the surface of the next muscle.

321. GLUTEUS MINIMUS (fig. 586) arises from the inferior gluteal area of the ilium as far back as the anterior border of the great sciatic notch, and as far forwards as the ilio-trochanteric band. The fibres converge to a tendon which begins on the surface of the muscle, and is inserted into a rough surface on the front and outer part of the great trochanter.

The portions of the two *glutei* attached to the ilio-trochanteric band represent a separate element, the *gluteus quartus* of other mammals. Its sheath, into which some of its foremost fibres are inserted, is continuous into the edge of the external ilio-femoral ligament, and is thereby connected with the deep origin of the ilio-tibial band. This corresponds to the *teres minor* of the upper limb.

Its nerve, the superior gluteal (4 and 5 l.), enters its outer surface, and its blood supply is derived from the transverse branch of the deep gluteal artery. It co-operates with the *gluteus medius*.

322. GLUTEAL ARTERY (fig. 586—from the internal iliac, § 281) escapes from the pelvis above the *pyriformis* through the upper part of the great sciatic notch, and lies on the small bare area of ilium between the *gluteus maximus* and *medius*. Here it is overlapped by its vein, and lies on its companion nerve, and gives off the external nutrient branch to the ilium. It divides into two branches—a **superficial**, which ascends and passes forwards into the *gluteus maximus*, breaking up into three or four large branches to supply the muscle, and a **deep** which passes forwards between the *gluteus medius* and *gluteus minimus*, and having supplied the *pyriformis*, divides into (a.) a superior branch which coasts along the superior gluteal line to end beneath the superior iliac spine by anastomosing with the external circumflex femoral artery, and (b.) an inferior branch which crosses the *gluteus minimus* to supply it, the hip-joint and the *tensor fasciæ femoris*, anastomosing with the external circumflex and sciatic arteries. Each of these branches is accompanied by two veins which have many valves; these unite as they approach the sciatic notch into one large gluteal vein. This artery is the serial homologue of the subscapular artery of the upper limb.

323. SUPERIOR GLUTEAL NERVE (from the lumbo-sacral cord, consisting of fibres from the posterior divisions of the ventral branches of the fourth and fifth lumbar, with some filaments from the first sacral) escapes external to the artery beneath and in front of its deep branches. Passing forwards between the *gluteus medius* and *minimus*, it divides into two branches,

324. PYRIFORMIS (fig. 586) arises within the pelvis from the intrapelvic surface of the costal elements of the second, third, and fourth sacral vertebræ. Escaping through the greater sciatic notch it tapers to a tendon which is inserted into the marginal facet at the upper part of the greater trochanter, behind the facet for the *obturator internus*.

It divides the greater sciatic notch into two parts—an upper through which the gluteal vessels and nerves emerge, between it and the *gluteus medius*, and a lower through which the inferior gluteal, sciatic and pudic vessels and nerves come out, between it and the *superior gemellus*.

Dissection. — Remove the upper portion of the *gluteus maximus*, exposing the whole of the greater sciatic ligament; remove also the whole *gluteus medius* from its origin, and trace the parts appearing below the *pyriformis*, which are as follows—

by two roots from the posterior *divisions** of the two upper sacral nerves, and ends by dividing into three sets of branches—(1) muscular, which pierce into the deep surface of the *gluteus maximus* (fig. 587, 2); (2) an articular branch to the hip; and (3) a cutaneous branch to the skin of the buttock (figs. 584, 2; 587, 4).

* See the use of this word in connection with the brachial plexus, p. 272.

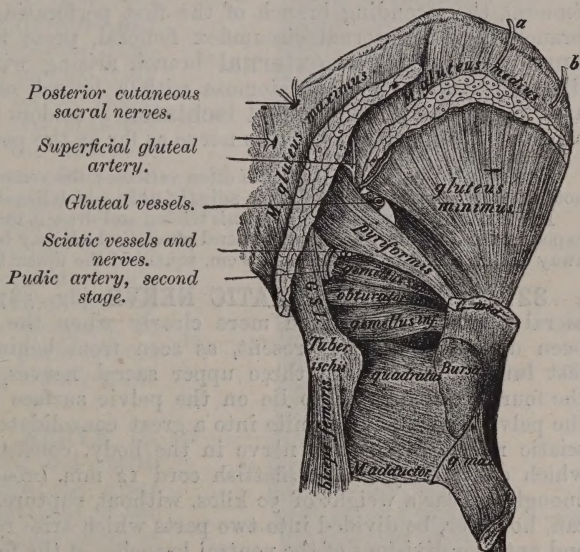


Fig. 586.—Deep muscles of the gluteal region.

which turns inwards over the origin of the *hamstrings*, internal to which it pierces the fascia to enter the perineum (p. 356). In the future dissection of the back of the thigh, the continuation of the small sciatic will be found becoming superficial through the **hiatus saphenus posterius**, to end in the skin of the popliteal space (fig. 584, 1). The cutaneous areas of these nerves are shown in fig. 590.

The recurrent **gluteal cutaneous nerve**, from the second sacral, may arise with the smaller sciatic, and has already (pp. 472, 475) been traced to the skin over the buttock (fig. 574, 2).

326. SCIATIC ARTERY (from the internal iliac, § 287), smaller than the gluteal, emerges above the greater sciatic nerve and passes downwards, lying upon the short rotator muscles of the hip. Its branches are—(1) **coccygeal**, which becomes superficial by piercing the greater sciatic ligament and ends in the *gluteus maximus*, the soft parts over the coccyx, and the coverings of the ischio-rectal fossa; (2) **inferior gluteal**, which accompanies the nerve of the same name into the *gluteus maximus*; (3) small **muscular** branches to the short rotator muscles, one of which passes beneath the *gemelli* and *obturator internus* along with the nerve to the *quadratus femoris*; (4) **anastomotie**, usually large, descending across the *quadratus femoris* and under cover of the great sciatic nerve, between the lower border of that muscle and the upper edge of the *adductor magnus*; it joins the terminal branch of the internal circumflex femoral, the ascending branch of the first perforating artery, and a transverse branch of the external circumflex femoral, these four making the **crucial anastomosis**; (5) an **external branch** arising with the last passes to the digital fossa, there to anastomose with a branch of the external circumflex artery; (6) the **comes nervi ischiatici** is seldom conspicuous, though often capable of being traced with its nerve as far as the popliteal space.

The **sciatic veins** are large and often varicose; the *venæ comites* of each branch in the notch usually unite to form the single **sciatic vein** which lies above and internal to the artery.

Dissection.—Divide the *pyriformis* tendon and draw it towards the middle line, thereby exposing the dorsal surface of the sacral plexus, which may be more clearly seen by cutting away with a chisel a portion about 8 cm. square of the upper border of the sciatic notch.

327. THE GREAT SCIATIC NERVE (fig. 587).—The structure of the sacral plexus will be seen more clearly when the cavity of the pelvis has been dissected, but at present, as seen from behind, the chief part of the last lumbar and of the three upper sacral nerves, with a small branch of the fourth, can be seen to lie on the pelvic surface of the *pyriformis*, behind the pelvic fascia, and to unite into a great consolidated continuation, the great sciatic nerve, the largest nerve in the body, consisting of about 38 bundles, which collectively form a flattish cord 12 mm. broad by 5 mm. thick, strong enough to bear a weight of 50 kilos. without rupture. The great sciatic nerve can, however, be divided into two parts which arise respectively from posterior and anterior divisions of the ventral branches of the fourth and fifth lumbar and three upper sacral nerves; the former portion being the **peroneal nerve**, the latter the **popliteal**. The conjoint cord emerges below the *pyriformis* and crosses over the short rotators of the hip about midway between the greater trochanter and the tuber ischii, beneath the *gluteus maximus* and external to the *hamstrings* (fig. 587, 1). Its subsequent course will be traced in a later dissection (p. 498). As it escapes through the sciatic notch its popliteal element gives off (1) a **branch to the obturator internus** (2 and 3 s.), which turns in through the lesser sciatic notch on the outer side of the pudic artery, having first given off a fine twig to the *gemellus superior* (2 s.). This nerve and the pudic nerve and artery can be followed subsequently by dividing the greater sciatic ligament and removing the loose tissue which covers them in the lesser sciatic notch.

The branch to the obturator ends by dividing into four branches, which enter the pelvic surface of the *internal obturator* muscle. A little lower, the great sciatic gives off (2) a branch to the *quadratus femoris*, which descends on the ischium under cover of the *gemelli* and the *obturator internus* tendon, and on the way sends off two fine filaments, one to the hip-joint and a second to the *gemellus inferior*.

From the hinder surface of the second and third sacral nerves before their union in the plexus two minute branches to the *pyriformis* arise. The superior gluteal nerve arises on a higher level from the lumbo-sacral cord, and the small sciatic arises behind the greater.

The lowest branch of the third, and the chief part of the fourth sacral nerve join with the whole of the fifth sacral nerve and with the first coccygeal, and form a plexus, the **pudendo-anal plexus**, which is quite separate from, and lower than the sacral plexus, lying inferior to the *pyriformis* on the pelvic surface of the *coccygeus*. Its branches are (1) short filaments to the *coccygeus*, *sphincter*, and *levator ani* (from the fourth sacral), inferior vesical, inferior rectal, and vaginal in the female. These visceral branches arise by four or five stems. (2) The ano-coccygeal or sub-caudal nerve, which pierces between the *levator ani* and the *coccygeus*, to end in the skin and soft parts around the coccyx. (3) The long branch is the pudic nerve (fig. 588).

328. THE PUDIC NERVE (p. 360), arising from the third and fourth sacral, passes out through the great sciatic notch below and internal to the great sciatic nerve, and under cover of the sciatic artery. Here it gives off a gluteal cutaneous branch, and winds round the spine of the ischium. It enters the lesser sciatic notch on the medial side of the pudic artery, and from thence runs in Alcock's canal in the obturator fascia on the outside of the ischio-rectal fossa, where its farther course has been already traced (p. 361, fig. 482).

329. PUDIC ARTERY.—The second stage of this vessel (§ 226) is here

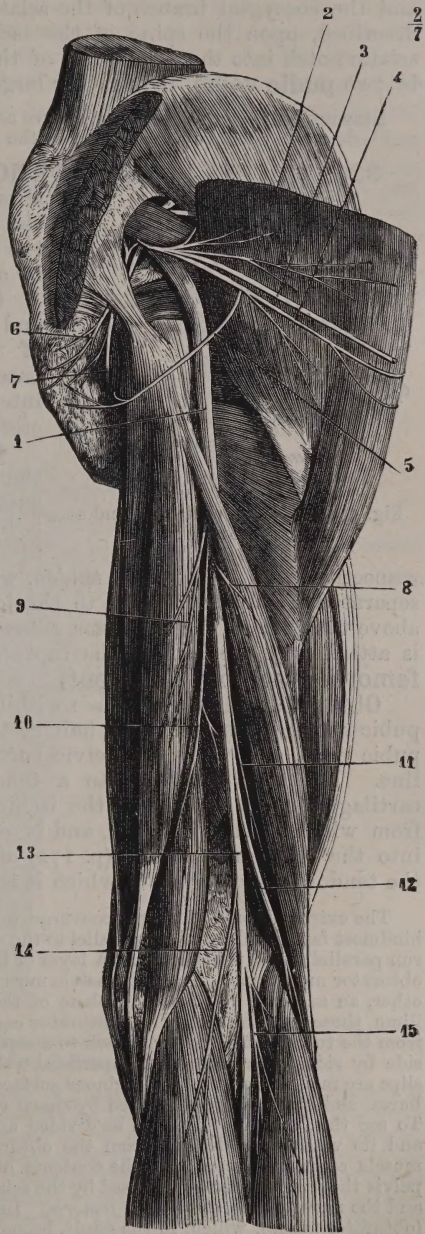


Fig. 587.—Branches of the sacral plexus, seen on raising the gluteus maximus.

short tendinous fibres from the outer edge of the tuber ischii outside the origin of the *semimembranosus*, and is inserted into the vertical line leading downwards from the tubercle on the posterior inter-trochanteric line, as far as the upper border of the insertion of the *adductor magnus*, to which its lower border is parallel. Its upper border is below and parallel to the *gemellus inferior*, with which it co-operates in rotating the femur outwards and adducting it.

Under the fat which lies beneath its upper border is the tendon of the *obturator externus*, while beneath its lower edge is the terminal branch of the internal circumflex artery (p. 492), and when this border is separated from the upper edge of the *adductor magnus*, the lesser trochanter, the *psoas* tendon and its bursa appear. It is covered by the *gluteus maximus*, sciatic nerves and vessels, and, at its origin, by the *semimembranosus*. It lies on the *obturator externus*, the internal circumflex artery, and its terminal branches. The quadratus femoris is a segmentation of the great adductor group of muscles, and its nerve is derived from the fifth lumbar, and comes off from the great sciatic (p. 476). It represents the coracobrachialis brevis of the upper limb.

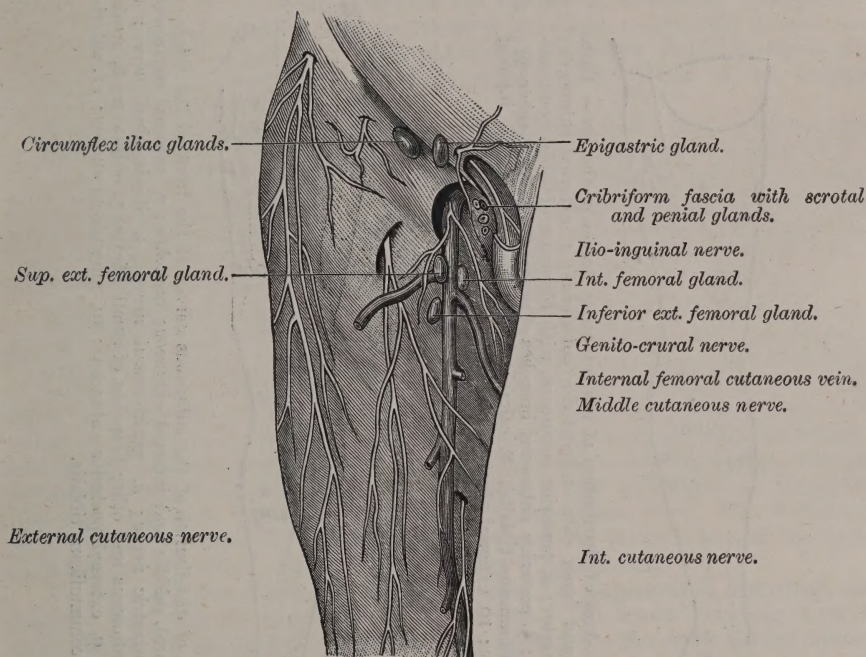


Fig. 589.—The front of the thigh, showing the saphenous opening and the cutaneous nerves, and inguinal lymphatic glands.

Dissection.—Divide this muscle along its line of origin and reflect it, clean the end of the internal circumflex artery (§ 353), which here divides into two branches, one ascending outwards beneath this muscle to the digital fossa to join the deep gluteal and sciatic arteries, the other ending in the crucial anastomosis. The *obturator externus* (§ 356) is a muscle of the adductor group, and will be examined later. Examine the sciatic ligaments (p. 169) and notches, and then divide the *gluteus minimus* tendon, and remove this muscle from the ilium. Clean the origins of the *hamstrings* at the tuber ischii. The *biceps* is the most superficial of these, and its origin can be traced over the tuberosity into the great sciatic ligament. It was primarily a *caudo-crural* muscle, but the shortening of the tail and the widening of the pelvis in man have caused its tendon of origin to be strained over the tuber ischii, to which it has consequently contracted a secondary attachment. The main body of the greater sciatic ligament is derived from this part of the *biceps* tendon with its sheath, which is strengthened by receiving the attachments thereto of the gluteal and obturator fascia.

The *semitendinosus* arises from the tuber on the inner side of the *biceps* and from that tendon. The *semimembranosus* arises from the ischial surface above and external to these, but its tendon at once crosses to the inner side anterior to the others. Their further dissection is described in §§ 365-367.

If time and the mutual arrangements of dissectors suit, the dissection of the popliteal space may next be proceeded with (§ 364) while the body is on its face.

Before turning the body, stitch together the cut ends of the greater sciatic nerve.

332. THE FRONT OF THE THIGH.—The body is to be turned on its back, with a block under the loins, and the legs extended, abducted, and rotated outwards.

Dissection.—Divide the skin along Poupart's ligament, and carry the inner end of the incision backwards along the side of the scrotum, and then downwards along the inner side of the thigh for about 15 cm. Make then a second transverse incision outwards across the thigh and reflect the flap of skin outwards. The skin is tied by radiating fibres to the fascia along Poupart's ligament, over the pubes, and at the great trochanter. The subjacent superficial fascia is thick, laminated, and fatty, containing in it the superficial vessels and nerves of the thigh. It is attached to the fascia lata along Poupart's ligament.

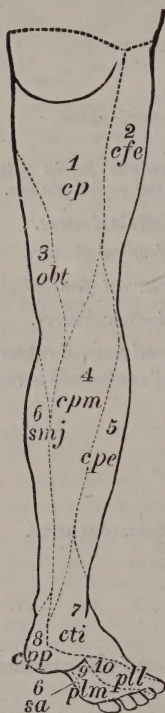


Fig. 590.—Area of distribution of the cutaneous nerves of the lower limb, back, and inner side—1, posterior cutaneous; 2, external cutaneous; 3, obturator; 4, posterior cutaneous, with filaments of tibial communicating; 5, posterior cutaneous branches of peroneal; 6, long saphenous; 7, communicans tibialis; 8, calcaneal of posterior tibial; 9, internal plantar; 10, external plantar.



Fig. 591.—Area of distribution of the cutaneous nerves of the front of the thigh—1, anterior crural, middle and internal cutaneous branches; 2, external cutaneous; 3, ilio-hypogastric nerve; 4, genito-crural nerve; 5, ilio-inguinal nerve; 6, posterior cutaneous and other branches of small sciatic; 7, obturator; 8, greater saphenous; 9, external posterior cutaneous; 10, musculo-cutaneous; 11, anterior tibial; 12, communicans tibialis.

Superficial Femoral Vessels.—Descending from the abdominal wall are two small veins, the superficial circumflex iliac near the superior iliac spine, and the superficial epigastric which descends from near the umbilicus; these converge as they enter the thigh and join the large **saphena vein** (p. 500), which ascends from the **rete dorsale venosum** on the foot, enclosed in fat along the inner side of the leg and thigh. Near the groin this saphena vein also receives an **external femoral cutaneous vein** from the outside of the thigh (fig. 589), and an **internal femoral cutaneous** from the skin over the adductor

muscles. Having received these and the superficial abdominal and external pubic veins, it sinks through an opening in the deep fascia to be subsequently described.

Accompanying these veins are arteries of much smaller size, branches of the femoral (p. 485), named respectively superficial circumflex iliac, superficial epigastric, pubic, and saphenous arteries.

Embedded in the fat of the groin around these vessels are about eight **inguinal lymphatic glands**. Two of these (**femoral glands**) are long and fusiform, lying one on the inner and one along the outer side of the saphena vein, and receiving the lymphatics from the front and inner sides of the thigh. About twelve large vessels enter these below, and four emerge above. A **superior external femoral gland** lies farther outwards above the end of the external femoral cutaneous vein, receiving the lymphatics of the outside of the thigh. The **iliac gland** lies on the circumflexa ilii artery, and receives the lymphatics of the iliac crest and flank. The **epigastric gland**, external to its artery, receives the cutaneous abdominal lymphatics; and **three pubic glands**, usually rounded in shape, receive the penial and scrotal lymphatics internally. The ascending branches from all these dip through the fascia beside the saphena vein; a small branch of the nearest artery enters each gland (fig. 589).

Superficial Nerves.—External to the saphena vein the cutaneous branches of the genito-crural nerve become superficial and descend to the skin of the thigh (p. 467). Outside this, and in a line below the superior iliac spine, the external cutaneous nerve pierces the fascia; while the middle cutaneous nerve becomes superficial about 10 cm. below the middle of Poupart's ligament. Close to the pubes the femoral branches of the ilio-inguinal are distributed, the areas of distribution of each nerve being shown in the diagram (fig. 591).

333. DISSECTION.—Having found these nerves, remove from below upwards the superficial fascia from the surface of the subjacent fascia lata. The saphena vein sinks through the deep fascia above a sharp crescentic edge of that membrane (fig. 589). The inner end of this crescent is lost in the fascia lata over the adductor muscles. The outer end can be traced upwards towards Poupart's ligament by cutting a number of irregular fibrous threads attached to it, so as to make an artificial border; at its upper part this extends inwards over the saphena vein to be attached to the under side of Poupart's ligament, and into the inner end of the ilio-pectineal line. This fascitious outer border is named the **falciform process** of the fascia lata, and its upper prolongation inwards is sometimes called **Hey's ligament**.

The opening thus artificially defined is called the **saphenous opening**, and appears oval, with its long axis nearly vertical. The fascia bounding it on its inner side is the **pectineal portion** of the fascia lata; the outer border defined by the knife is the falciform process of the fascia lata; below it is bounded by the **fascial crescent**, above by Hey's ligament. The filaments of connective tissue which were attached to the falciform process, surround the vessels which traverse the saphenous opening, and become lost internally in the superficial fascia over the pectineal portion of the fascia lata. This indefinite structure is called the **cribriform fascia**. The vessels which go through the holes of this sieve are the superficial abdominal arteries above named except the pubics, and sometimes their veins, the lymphatics, and the saphena vein.

The saphenous opening is important, as through it a femoral hernia bulges when it becomes complete.

Gimbernat's Ligament.—Dissect off the upper prolongation of the falciform process from the lower border of Poupart's ligament. From the attachment of that ligament to the spine of the pubis a triangular expansion is continued

backwards and outwards for 2 cm. along the ilio-pectineal line. This shelf-like horizontal process is *Gimbernat's ligament*; it presents a crescentic outer edge towards the femoral vessels (p. 170, fig. 261).

334. FEMORAL SHEATH.—When the falciform process of the fascia lata is raised from the subjacent vessels, they appear still invested by a distinct fibrous envelope, the *femoral sheath*, the margins of which can be easily isolated below Poupart's ligament by scraping with the handle of the knife. It consists of a firm fibrous layer in front of the vessels continuous through the crural arch with the fascia transversalis (§ 243). The layer which lies beneath the vessels is continuous above with the fascia iliaca, and below with the pectineal portion of the fascia lata. These two layers are joined together both external and internal to the vessels. In this femoral sheath there are three compartments—

an outer, containing the femoral artery, a middle, containing the femoral vein, and an internal smaller, containing the ascending lymphatic trunks and usually a small lymphatic gland (fig. 592). These three compartments are separated from each other by strong septa. As the lymphatics only enter the sheath at the level of the saphenous opening, the third compartment is only traceable downward into the thigh for 1 cm. This lymphatic compartment is closed above by a thick layer of the sub-peritoneal areolar tissue, called the **septum crurale internum**, which is pierced by the ascending lymphatics.

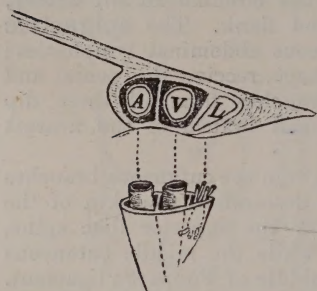


Fig. 592.—Scheme of the femoral sheath, seen above as cut through behind Poupart's ligament; seen below on its anterior surface—A, arterial compartment; V, venous; L, lymphatic compartment or femoral ring.

In the female, although the archway beneath Poupart's ligament is not larger than in the male, yet on account of the smaller muscles and weaker fasciae, this third canal has weaker boundaries, and into it a portion of intestine may be forced, constituting a **femoral hernia**. The lymphatic compartment of the sheath has, therefore, a certain surgical importance, and is called the **crural canal**, having the process continued downwards from the transversalis fascia in front, the pectineal portion of fascia lata (which is continuous above with the fascia iliaca) behind, the union of these two internally, and the septum which divides it from the vein externally. The opening whereby this crural canal communicates with the abdominal cavity is called the **femoral ring**; it can be shown from the abdomen by removing the peritoneum and septum crurale from the inferior digital fossa (p. 386) which is opposite the top of the canal, or it may be shown from below by opening the front of the canal and pushing the finger upwards into the abdomen. This ring is bounded in front by the crural arch and fascia transversalis, behind by the fascia iliaca, internally by the edge of Gimbernat's ligament, externally by the partition which separates it from the vein. A hernia lying in this canal is covered by (1) skin, (2) superficial fascia, (3) cribriform fascia, and (4) the front wall of the sheath; it has also pushed before it (5) an expansion from the septum crurale over (6) its peritoneal sac. Such a hernia is, however, liable to burst through the front wall of the sheath, where it is weakened by the entrance of the lymphatic trunks, and to burrow through the cribriform fascia; and as this is inseparable internally and below from the superficial fascia, the fundus of a complete femoral hernia must needs follow the line of least resistance and turn upwards and inwards over Poupart's ligament and the pubic spine. In such a case it is only covered by the first, second, fifth, and sixth of the structures just enumerated. Tightness of the ring may cause strangulation of a hernia, and this can usually be relieved by dividing the edge of Gimbernat's ligament where it joins Poupart's.

Dissection.—Divide the skin down the middle of the thigh to the level of the tubercle of the tibia, and there cut it transversely, reflecting it in two lateral flaps. In the superficial fascia thus exposed trace downwards the external cutaneous, the genito-crural, and the middle and internal cutaneous nerves.

335. EXTERNAL CUTANEOUS NERVE.—This nerve, whose origin from the posterior division of the second lumbar has been already described

(p. 467), descends over the *iliacus* and the deep circumflex iliac artery, and passes beneath Poupart's ligament, lying for a short distance (5 cm.) in a canal of fascia lata, out of which it sends backwards its **cutaneous gluteal branch** (fig. 584, 6). Becoming superficial it descends over the extensor muscles and supplies the skin of the outside of the thigh as far as the knee, over which it sends a branch to the patellar plexus (fig. 589).

336. THE MIDDLE CUTANEOUS NERVE has arisen from the anterior crural above the crural arch (p. 467), either as two parallel cords or as a short common stem which divides at once into two cords, the outer of which pierces and supplies the *sartorius* muscle, and, becoming cutaneous in the middle third of the thigh, supplies the skin as far as the knee. The inner branch becomes superficial at a point higher up on the thigh, and supplies the skin internal to the area of distribution of the last above the patella, internal to which it sends branches to join the succeeding nerves.

337. THE INTERNAL CUTANEOUS NERVE is a group of two or three small nerves from the anterior crural, sometimes united into a single cord. One of these pierces the fascia lata close to the saphena vein at the middle third of the thigh, and descends with that vein; the second pierces the fascia at the lower third of the thigh, and sends branches downwards and outwards to the inner side of the patella and of the tibial tubercle. The largest of these branches joins, below the patella, with branches of the middle and external cutaneous, making the subcutaneous **patellar plexus**. The **superior cutaneous** branch of the obturator nerve joins the internal cutaneous at the edge of the *adductor longus*, and is traceable down to this plexus, which is joined by a branch of the long saphenous nerve. The upper branch of the internal cutaneous is often connected with the nerve to the *pectineus* (p. 467).

338. PREPATELLAR BURSÆ.—Between the skin and the superficial fascia at the lower edge of the patella there is often a **subcutaneous bursa** of small size. Beneath the superficial fascia and over the fascia lata there is always a large **interfascial bursa** intersected by smooth fibrous bands extending downwards over the upper part of the patellar ligament. Still deeper, between the deep fascia and the front of the bone, there is a layer of lax connective tissue, and sometimes a third or deep **subfascial bursa** (figs. 277, 285).

These bursæ appear in foetal life, and they vary in size in persons of different occupation, being often large in housemaids, carpet-nailers, &c., often communicating with each other.

Dissection.—Remove the superficial fascia and clean the underlying deep fascia.

339. THE FASCIA LATA is a strong fibrous membrane consisting of an outer stratum of oblique or nearly transverse fibres and a deeper of longitudinal. It is attached above to the iliac crest, being a continuation forwards of the gluteal fascia, but is continuous with Poupart's ligament, and extends upwards therefrom as **Scarpa's fascia** on the abdomen (fig. 503). It is attached internally to the ilio-pectineal line (along which it is continuous with the fascia iliaca) to the pubic crest and ilio-pubic ramus, along which it is connected to the deep perineal (Colles's) fascia. It is pierced by the saphenous opening (*cf.* hiatus semilunaris brachii—p. 282) and by the cutaneous nerves, and sends in to the linea aspera three intermuscular septa separating respectively the extensors, flexors, and adductors from each other.

Along the outer side of the thigh a special strip of the longitudinal fibres of the fascia is strengthened by receiving fibres from the tendons of the *gluteus maximus* and from the *tensor fasciæ femoris*, and this flat band descends to the knee, and is inserted into the external tuberosity of the tibia. This band is called the **ilio-tibial ligament**, and its fibres, when traced upwards, divide

into two strata, a superficial overlying the *tensor fasciæ femoris* muscle, and attached to the lower lip of the outermost part of the iliac crest over the *gluteus medius*; and a deeper attached to the inferior iliac spine behind and external to the *rectus* and *iliacus* and to the great trochanter, sheathing the upper part of the *vastus externus*. It is an important factor in maintaining the upright position of the body.

Remove the fascia lata from the surface of the *tensor fasciæ* muscle below the iliac crest.

340. TENSOR FASCIÆ FEMORIS (fig. 593, 8), lying on the outer margin of the upper third of the thigh, arises from the anterior 2 cm. of the iliac crest, and from the surface of the fascia which underlies it. It descends, enclosed between two layers of fascia, and expands below, to be inserted into the fascia lata about 10 cm. below, and on a plane in front of the great trochanter. It lies between the *gluteus medius* behind and the *iliacus* in front, and is pierced behind at its middle third by the terminal branch of the superior gluteal nerve (4 and 5 l.) which supplies it. It receives branches from the deep gluteal and external circumflex arteries. It makes tense the fascia lata, and can flex and rotate inwards the thigh, and through the ilio-tibial band can maintain the knee in the extended position. It corresponds to the acromial deltoid of the upper limb.

Dissection.—Divide the fascia over the *sartorius* muscle and clean its surface as far as its insertion into the tibia.

341. SARTORIUS (fig. 593), the longest muscle in the body, arises from the anterior face of the superior iliac spine and from a small portion of the ridge below it. It descends as a flat ribbon-like band whose cross-section is nearly equal throughout, at first downwards and inwards, then downwards and backwards, then directly downwards, and at last downwards and outwards, becoming tendinous below the knee-joint, and inserted by a concavely-margined tendon into an oblique line on the tibia below and internal to the tubercle.

It is covered only by skin and fascia, pierced by part of the middle cutaneous nerve with which its own nerve of supply from the anterior crural (third lumbar) usually enters it. From above downwards it crosses over the *iliacus*, *rectus*, anterior crural nerve, the femoral vessels, *pectineus*, *adductors longus* and *magnus*, *vastus internus*, the inner side of the knee-capsule, and the inner side of the tibia. It is enclosed in a sheath of fascia lata. As it descends behind the knee, the saphena vein and nerve lie along its posterior border, and its termination lies anterior and superficial to the tendons of *gracilis* and *semitendinosus*. Its action is complex, flexing the hip and abducting it, rotating the leg a little inwards at the knee, and so co-operating with the *gracilis* and *semitendinosus* to undo the outward locking rotation of the knee preparatory to flexion (p. 191). *Sartorius*

Fig. 593.—Muscles on the front of the thigh—1, psoas; 2, iliacus; 3, pectineus; 4, adductor longus; 5, adductor brevis; 6, gluteus medius; 7, gracilis; 8, tensor fasciæ femoris; 9, sartorius; 10, rectus femoris; 11, vastus internus; 12, vastus externus; 13, wall of prepatellar bursa; 14, patella; 15, ligamentum patellæ.

is the equivalent of the *dorsi-epitrochlearis* of the upper limb, and is a segmentation from the extensor mass of muscles (p. 290).

Dissection.—Remove the fascia lata from the front of the thigh and clean the underlying parts. From the deeper layer of the fascia at the knee fibres pass to each side of the patella

from the femoral condyles, forming superficial **retinacula** for the patella. Expose the surface of the *adductor longus* muscle, and open the sheath of the femoral vessels.

342. SCARPA'S TRIANGLE.—At the upper part of the thigh is a triangular space whose base is formed by Poupart's ligament, its outer side by the *sartorius*, its inner by the *adductor longus*. The floor of the space consists of the *pectineus*, occasionally a small part of the *adductor brevis*, the *adductor longus*, the tendon of the *psaos*, and the *iliacus*. Between the two last named the anterior crural nerve descends; and lying on the *pectineus* and *adductor longus* are the femoral vessels, which should next be exposed.

343. FEMORAL ARTERY, the continuation of the external iliac (§ 286), commences on the ilio-pubal eminence. Its course may be divided into two stages—that in Scarpa's triangle and that in Hunter's canal. In its first stage it descends to the apex of the triangle, and is only covered by skin, superficial fascia, the femoral lymphatics, the fascia lata, and the anterior layer of the femoral sheath. It lies upon the ilio-pubal eminence, the *psaos* tendon, the capsule of the hip-joint, and the nerve to the *pectineus* muscle; but its own

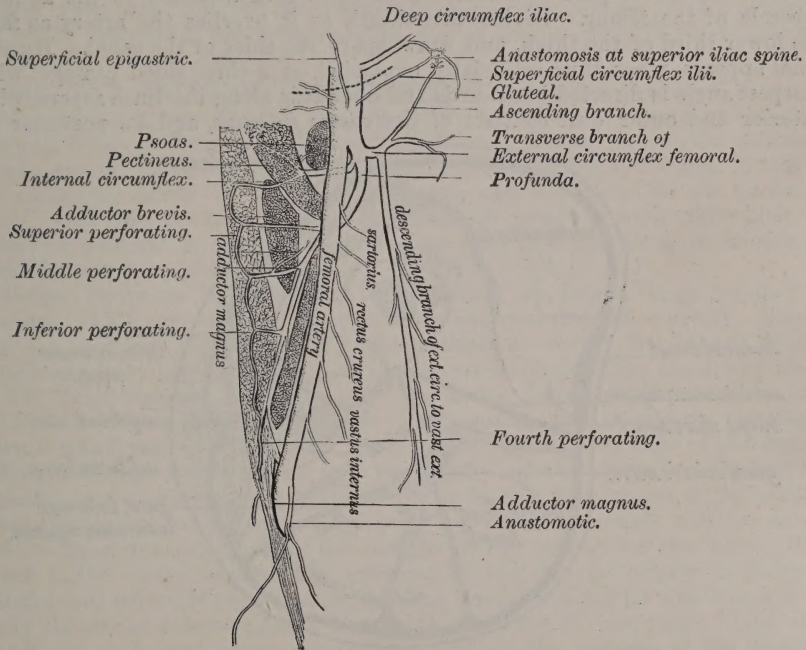


Fig. 594.—Scheme of left femoral artery.

vein, its own branch the profunda and the profunda vein, as well as the pectineal portion of the fascia lata, are interposed between it and the *pectineus* muscle. At the apex of the space it lies on the *adductor longus*. The *iliacus* muscle and anterior crural nerve lie external to it; and its own vein lies at first internal, but at the apex of the space is posterior to it.

The branches arising from the femoral artery in Scarpa's triangle are (1) **superficial epigastric**, which pierces the sheath to ascend on the abdominal wall (§§ 234 and 332); (2) **superficial circumflex iliac** (*ib.*); (3) **superior pubic**, which runs inwards to be lost in the suprapubic fat; (4) the **inferior pubic** is an inconstant branch arising lower down and running inwards under the fascia lata to supply the skin covering the spermatic cord and the side of

the scrotum; (5) **saphenous**, one, two, or three branches descending to the skin and lymphatic glands external to the saphena vein. (6) **Profunda femoris**, a very large branch, arises about 4 cm. below Poupart's ligament from the outer and deep surface of the femoral trunk. It descends at first outwards and downwards, then downwards and inwards, crossing beneath the femoral artery, from which it is separated by the femoral and profunda veins (§ 353). (7) Near the apex of Scarpa's triangle the femoral artery gives off muscular branches to the *rectus femoris* and to the *sartorius*.

The portion of the femoral above the profunda is the common femoral; the portion below is the superficial femoral.

344. HUNTER'S CANAL.—On raising the *sartorius* in the middle third of the thigh a fascia appears beneath it, consisting of oblique fibres stretching downwards and outwards from the surface of the *adductor longus* to that of the *vastus internus*. This sheath, which is derived essentially from the adductors, being a degenerated stratum of the muscle, gradually strengthens as it descends until at its lowest part it becomes a rounded cord attached to the adductor tubercle of the femur. Divide this sheath as it overlies the artery as far as the lower third of the thigh, and draw apart the sides of the canal. Hunter's canal appears, when thus artificially expanded, as a three-sided passage, whose sharpest angle is directed backwards and outwards along the linea aspera, whose anterior and outer wall consists of the *vastus internus*, and its posterior and

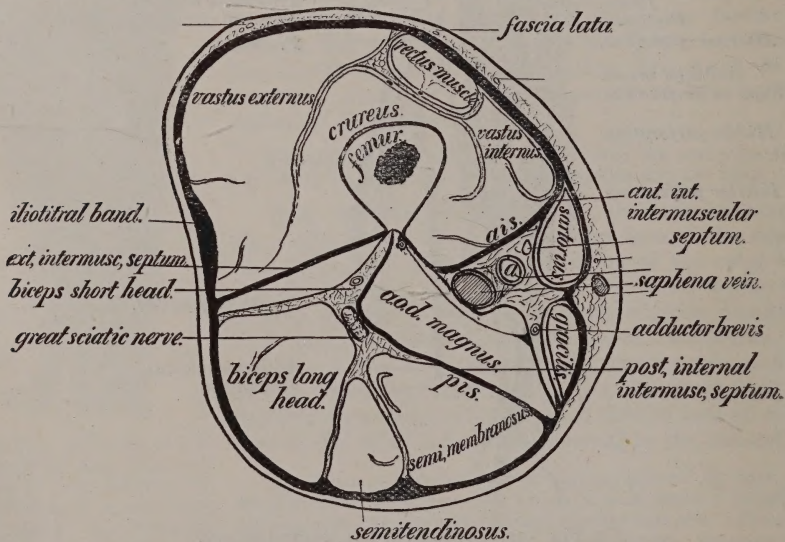


Fig. 595.—Transverse section of right thigh across the middle of Hunter's canal.

internal wall of the *adductor longus* above and *adductor magnus* below, while its base is the fascia just described under the *sartorius*. At its lower end the artery sinks through the tendon of the *adductor magnus* and enters the popliteal space, changing its name and becoming the popliteal artery (§ 369). In this canal the femoral vein lies behind the artery, becoming posterior and external below, but closely tied to the artery by a firm areolar sheath. In its whole course the femoral artery, from lying on a plane anterior to the femur, has passed to the level of the inner side of the bone at the apex of Scarpa's triangle, and recedes still more in Hunter's canal, until finally it has passed behind the level of the bone as it enters the popliteal space (fig. 595).

In Hunter's canal the superficial femoral artery gives off (9) **muscular** branches to the boundary muscles of the canal, and close to its lower end (10) the **anastomotica**. This vessel arises from its front and inner side, and divides at once into a superficial and a deep branch; the former pierces the roofing fascia and descends with the saphena vein between the tendons of the *sartorius* and *gracilis*, to terminate in the articular rete; the deep branch pierces into the *vastus internus*, in front of the tendon of the *adductor magnus*, and descending to the inner side of the knee ends also in the rete, sending a branch across the femur to the outer side of the bone.

The femoral artery can be felt pulsating in Scarpa's triangle. Its vasomotor nerves, derived from the anterior crural, descend on its anterior surface. It averages 8 mm. in diameter. For the homologies of these vessels, see § 369.

345. THE FEMORAL VEIN, whose relations to its artery have been noted, receives from below upwards the venæ comites of the muscular and profunda branches, and at the saphenous opening it receives the saphena and the superficial abdominal veins. The vein possesses three pairs of valves, and is alternately pressed upon and relieved from pressure during the action of the *adductor* and *vastus internus* muscles in walking, and is thus emptied upwards into the external iliac vein (§ 292).

346. THE ANTERIOR CRURAL NERVE arises from the dorsal divisions of the lumbar plexus (§ 314), and descends between the *psaos* and *iliacus*, emerging between them under Poupart's ligament. Before leaving the abdomen it has given off three branches to the *iliacus* muscle (third and fourth lumbar); the vasomotor nerve to the femoral vessels, and the nerve to the *pectineus* which descends inwards behind the femoral vessels; with this nerve a cutaneous filament is often united, and in this case the stem is sometimes called the accessory obturator (§ 314).

Below Poupart's ligament the nerve breaks up into a large number of branches, which surround the division of the external circumflex artery. Superficial to this artery there pass the middle cutaneous nerves, the branch to the *sartorius* and the internal cutaneous nerves, while deeper than the artery there are five large branches, the branch to the *rectus femoris*, which descends and divides into two or three as it enters that muscle; the branch to the *vastus externus* which passes beneath the *rectus* and along the front edge of the *vastus*, sending branches to the front and outer edge of the *crureus*. Both these branches send down articular branches to the knee. The branch to the *crureus* enters that muscle on its inner edge, and its continued trunk will be subsequently found descending along the margin of the *crureus* to the knee. The branch to the *vastus internus* lies external to the femoral artery in Scarpa's triangle, and enters Hunter's canal, sending branches along its whole course to supply the *vastus internus*, and a large articular twig to the joint. The last branch, the saphenous nerve, descends at first on the outside of the femoral artery, but crosses to its inner side in Hunter's canal, which it leaves below along with the anastomotica artery, becoming superficial. As it descends with the saphena vein behind the *sartorius* tendon, it gives off articular and patellar branches, and its continued trunk will be found in the leg, supplying the skin on the inner side as far as the ball of the great toe. This nerve represents that portion of the musculo-spiral nerve in the arm which derives its filaments from the fifth and sixth and part of the seventh cervical nerves, and which is distributed in the arm. The part representing the forearm portion of the musculo-spiral has become separated as the peroneal nerve (§ 375).

Dissection.—Divide the *sartorius* at its upper fourth and reflect it upwards and downwards. Divide also the *tensor fasciæ femoris*, and trace the fascia underlying it which forms the deep root of the ilio-tibial band. Remove the fat external to the *iliacus* muscle, and expose the origin and course of the *rectus* muscle.

The several parts of the extensor muscles of the thigh are more clearly differentiated than are the corresponding parts of the *triceps* extensor in the arm, and exceed the flexors in bulk in the proportion of 68 : 31. They occupy the whole surface of the shaft of the femur except the *linea aspera*. The component muscles are four, which form collectively the **quadriceps extensor cruris**.

347. RECTUS FEMORIS (fig. 593) arises by two tendinous heads—one flatter, smaller, and curved from an impression above the brim of the acetabulum, below the *gluteus minimus*; the other larger and straighter from the inferior iliac spine. These heads unite at an angle of 45° to form a narrow triquetrous tendon from the deep surface of which fleshy fibres arise. The tendon of origin is prolonged in front of the muscle for the upper third, rendering smooth its surface where the *sartorius* glides over it, but below this level it narrows into a median tendinous line. The muscular fascicles arising therefrom descend in two lateral series, diverging at an angle of 36° from each other, thereby giving a bipenni-form appearance to the fusiform belly of the muscle, each fascicle being about 0.2 of the entire length of the muscle. The posterior fascicles descend vertically. The tendon of insertion begins on the deep surface of its upper fourth as a flat lamella, into whose surface and edges the fascicles are inserted. Above the patella this tendon narrows to a flat band into the margins of which the *vasti* tendons are inserted, and it is inserted into the upper edge and anterior surface of the patella.

The nerve from the anterior crural (3 l.) enters the *rectus* at its upper third, and its arteries are from the external circumflex and femoral. It is superficial below the level at which the *sartorius* crosses it, and it lies on the *iliacus* (which is also internal to it), the deep origin of the ilio-tibial ligament, the branches of the external circumflex artery and anterior crural nerve, and the *crureus* muscle.

Of the two heads the acetabular is the primary, the other develops early in the third month as a secondary thickening of the sheath, owing to the change of axis of the limb consequent on the assumption of the capacity of full extension of the hip and knee. The muscle acts chiefly from its straight head when the hip is extended, but from its curved head when it extends the knee during flexion of the hip. The axis of the *rectus* being oblique, it draws the patella upwards and outwards, extending the knee and flexing the hip.

Divide the *rectus* in the upper third and reflect it. Dissect the fascia lata from the outer surface of the *vastus externus* and draw that muscle forwards, separating it as far as possible from the external intermuscular septum. The division of the remaining part of the extensor mass into its parts is a matter of some difficulty, as the *vastus externus*, though superficially separable from the *crureus*, is fused with that muscle close to the bone; while the *vastus internus*, though perfectly separate at its bony origin, is inseparable superficially and at its insertion from the *crureus*. Close to the patella these muscles may be dissected apart, and above, the nerve to the *crureus* dips in between them, so, if the line of separation be carried artificially through the muscle from the patella to the nerve, it will be seen that the fusion of these muscles is only on the surface, and that a bare strip of bone nearly the whole length of the inner edge of the femur separates the origin of the *vastus internus* behind from that of the *crureus* in front, while along the inner edge of the origin of the *crureus* the articular branch of the nerve to the *crureus* is continued along its margin down to the knee-joint.

Vastus externus arises by a tendinous plane from the ridge at the anterior part of the root of the great trochanter extending down from the tuberculum colli superius, from the outer edge of the rough gluteal line, and from the outer lip of the *linea aspera*, and from the surface of the bone immediately external to it, as well as from the lower half of the external intermuscular septum. Its fibres descend from this tendon forwards at an angle of about 20° from the perpendicular, to be inserted, by a widely expanded tendon beginning beneath the muscle, into the outer border of the tendon of the *rectus*, and *crureus* into the outer edge of the patella, and by the external patellar ligament, whereof it forms the largest part, into the outer part of the head of the tibia.

Its nerve enters along its anterior edge along with descending branches of the external circumflex artery. The *tensor fasciæ femoris*, *rectus*, fascia lata, *gluteus maximus*, and infragluteal bursa cover it.

Crureus (figs. 593, 595), with difficulty separable at its origin from the last, arises by a series of successive fleshy lamellæ from the front and outer surface of the femur as far inwards as the long articular nerve. Its fascicles soon end in a superficial tendon, which appears first on the outward and upper part of the muscle, and is inserted into the upper edge of the patella inseparable from the *vasti*. Its nerve arises along with that to the *vastus externus*, and its arteries spring from the external circumflex and femoral. Its lowest lamella often misses the patella and is inserted into the surface of the synovial pouch, which extends from the knee-joint under the tendon of this muscle (**the suberureal bursa**—fig. 277), and which always communicates with the knee-joint in the adult though originating independently. The portion of this muscle thus attached to the synovial membrane is called *suberureus*, and is supplied by filaments which descend in the long articular nerve, but it is rarely differentiated into an independent muscle. The *crureus* underlies the *rectus* and overlies the bone.

Vastus internus arises, narrow above, from the inner lip of the linea aspera and of its internal prolongation downwards, and from the septum between it and the adductors. It thickens as it descends, and its fibres pass very obliquely (40°), to be inserted into the inner edge of the tendons of the *crureus* and of the *rectus*, and into the inner side of the patella; none of the fibres are extended into the internal patellar ligament, but the fibres of the fascial sheath, descending from the patella to the inner side of the head of the tibia, cross its fibres obliquely. In extending the knee it draws the patella upwards and inwards. It is fleshy lower than any other part of the *quadriceps* (fig. 285).

The most important relations of the *vastus internus* are to the femoral artery and vein, with which, as the outer wall of Hunter's canal, it is in contact. It is overlapped by the *sartorius*, and its upper part lies deeply buried in the floor of Scarpa's triangle beneath the femoral vessels. Its nerve descends in Hunter's canal, and sends a succession of filaments into the muscle on its inner surface.

The ligamenta patellaria medium et externum are the tendons of the *quadriceps extensor* muscle, in which the patella is a sesamoid bone. The resultant of the whole muscular mass acts in a line joining the inferior iliac spine to the middle of the patella.

Dissection.—Divide the femoral artery at the apex of Scarpa's triangle and reflect it. Remove the fascia lata from the adductor group of muscles, flex the knee, and abduct the thigh.

348. GRACILIS (fig. 593), ribbon-like and superficial, the innermost muscle of the thigh, arises by a thin flat tendon from the lower half of the margin of the symphysis, and the inner edge of the inferior pubic ramus. This soon becomes fleshy and descends, narrowing and thickening, to a rounded tendon, which passes over the internal lateral ligament of the knee, behind the *sartorius*, and separated therefrom by the saphenous vein (which is, however, over the fascia) and nerve, and a branch of the anastomotica artery. It is inserted into the upper part of a small oblique line on front of the tibia below its head, beneath the tendon of the *sartorius*, and above that of the *semitendinosus*.

A bursa underlies these two tendons. The muscle is covered only by skin and fascia, and below by the *sartorius* tendon; it lies on the *adductors brevis* and *magnus* and the capsule of the knee. Its nerve is a branch of the superficial obturator, and its arteries are from the internal circumflex and femoral. This muscle co-operates with the *semitendinosus* in rotating the leg inwards in the first stage of flexion. It is normally unrepresented in the upper limb, its homologue, the *chondro-epitrochlearis*, being a rarely present muscle (p. 266).

349. ADDUCTOR LONGUS arises by a narrow tendon from the front of the pubis below its crest. This soon becomes fleshy, and descends outwards and backwards, expanding and forming the inner boundary of Scarpa's triangle and of Hunter's canal. It is inserted by short tendinous fibres into the internal intermuscular septum along the inner lip of the linea aspera for its lower two-

thirds, and into a short extent of the internal popliteal line. It is covered by the skin, fascia, *sartorius*, and femoral vessels, and gives off from its anterior surface the fascial roof of Hunter's canal. It lies on the *adductors brevis* and *magnus*, from which it is separated by the anterior branch of the obturator nerve, which supplies it (2 and 3 l.) and gives off the vasomotor filaments to the profunda artery.

The cutaneous branch of the obturator nerve winds round its inner edge to join the internal cutaneous nerve.

Its upper border is parallel to the edge of the *pectineus*, and its upper fibres are $\frac{1}{35}$ of the length of the lowest, which are not easily separated from the *adductor magnus*. Into the *adductor longus* pass arteries from the femoral and profunda. In the female, the edge of the next muscle usually appears in the floor of Scarpa's triangle between this and the *pectineus*.

Divide the tendon of origin of the *adductor longus*, and reflect the muscle outwards.

350. ADDUCTOR BREVIS arises from the front of the ischio-pubic ramus below the *adductor longus* and *pectineus*, internal to the *obturator externus*, external to the *gracilis*, and above the *adductor magnus*. From this circumscribed origin it descends, expanding, to be inserted into the line leading from the lesser trochanter to the linea aspera, and into the upper third of the linea aspera. Neither this nor the last muscle are represented in the upper limb.

It is usually divided into two parts at its insertion by the middle perforating artery, and the upper of these is inserted by a thin tendon, under the upper edge of which there is sometimes a bursa. It has the *pectineus* (sometimes), *adductor longus*, and profunda artery, with the anterior branch of the obturator nerve in front, and it lies on the posterior branch of the obturator nerve, which supplies it (2 and 3 l.), the *adductor magnus*, and the *obturator externus*. From the last it is separated by the internal circumflex femoral artery.

351. PECTINEUS (fig. 596), seen by drawing the common femoral artery outwards, lies external to, and on the same plane as, the *adductor longus*. It arises from the anterior surface of the ilio-pectineal line and the fascia which covers it, and glides over the triangular surface below the line, descending outwards, to become tendinous as it is inserted into the line behind the lesser trochanter which leads to the linea aspera.

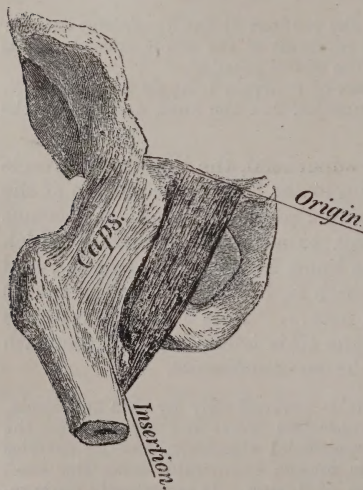


Fig. 596.—Pectineus.

It is a quadrate, often bilaminar muscle, especially externally, and is covered by the pectineal portion of the fascia lata, the femoral and profunda vessels, and Gimbernat's ligament. It lies upon the hip-capsule, *obturator externus*, *adductors brevis* and *magnus*, and obturator nerve. Externally it is separated from the *psaos* by the internal circumflex artery. Its nerve from the anterior crural (3, 4 l.) enters its upper and outer part; there may (but rarely) be a second nerve from the anterior part of the obturator. This muscle is morphologically a segmentation from the *iliacus*, functionally associated with the adductor group, and has no representative in the upper limb in man.

Dissection.—Divide the *adductor brevis* close to its origin and expose the next muscle.

352. ADDUCTOR MAGNUS (fig. 597) consists of two usually separable parts, the largest and lowest of which arises from the rough lowest part of the tuber ischii and from the continuation of this area on the ramus in front as it tapers to a ridge. From this it descends, expanding into a fasciculated sheet imperfectly divisible into two parts, a longer or condylar portion, which descends to be inserted into the internal intermuscular septum and into the adductor tubercle of the

femur, and a posterior portion which passes outwards behind the profunda artery to the linea aspera for nearly its whole length. This portion is inserted by short tendinous fibres into the bone, and is pierced along its insertion by the perforating branches of the profunda artery, the hole for each being crossed by a tendinous arch.

Between the lower border of this portion and the condylar part there is a deficiency at the lower end of Hunter's canal, through which the femoral vessels enter the popliteal space. This muscle is supplied by the posterior branch of the obturator nerve and by a branch of the great sciatic behind. It is represented in the upper limb by the *coraco-brachialis* muscle.

The second portion of the *adductor magnus* is sometimes described under the name *adductor minimus*, and is widely triangular, lying above and behind the rest of the muscle. It arises below the *adductor brevis* from the ischial ramus, its upper fibres pass horizontally outwards, and end in a thin flat tendon which glides over the back of the lesser trochanter, and it is inserted into the inner margin of the gluteal ridge of the femur; its lowest fibres descending as far as the archway for the middle perforating artery.

Its upper border is parallel to the lower edge of the *quadratus femoris*, from which it is separated by the end branch of the internal circumflex artery. In front is the *adductor brevis*, behind the greater sciatic nerve and the *hamstring* muscles, and below the rest of the *adductor magnus*.

Dissection.—Replace now the adductors, and trace the profunda femoris artery, which is now exposed for its whole length.

353. THE PROFUNDA FEMORIS ARTERY (§ 343) arises from the outer side of the common femoral, and descends at first downwards and outwards, then downwards and inwards, lying on the *iliacus*, *pectineus*, *adductor brevis*, and *adductor magnus*. It underlies the femoral artery, the femoral and profunda veins, and the *adductor longus* muscle. In its course it gives off the following branches:—(1) **External circumflex**, a short trunk passing outwards on the *iliacus* through the branches of the anterior crural nerve, and beneath the *sartorius*. This divides into (a.) a branch of the *rectus*; (b.) a branch to the *crureus*; (c.) a large branch, often arising separately, to the *vastus externus*, which runs towards the knee beneath the *rectus* and along the anterior border of the *vastus*; (d.) a transverse branch which pierces the *vastus externus* to wind round

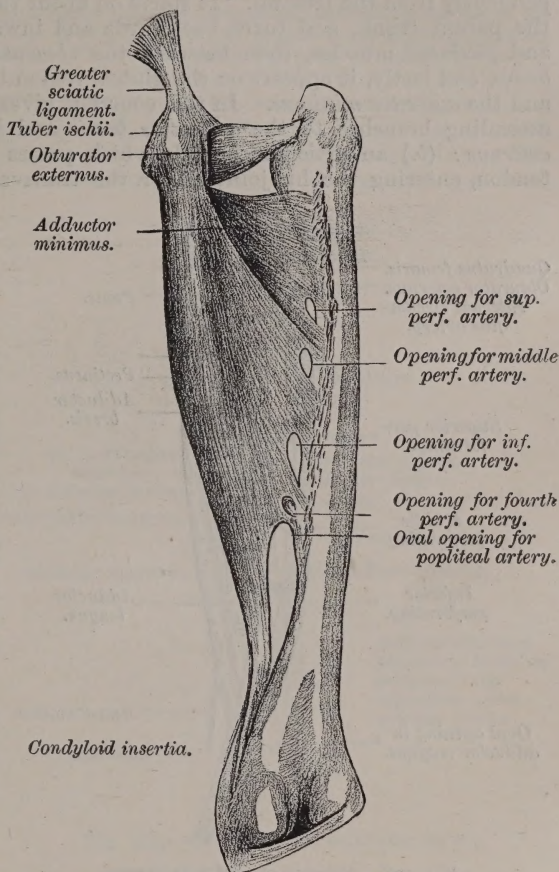


Fig. 597.—Adductor magnus, seen from behind.

the femur to the crucial anastomosis; (e.) an ascending branch which passes upwards beneath the *tensor fasciæ femoris*, towards the gluteal artery (fig. 594).

(2) **Internal Circumflex Artery.**—This, like the last, may arise independently from the femoral. It starts on about the same level as the last from the parent trunk, and turns backwards and inwards, first between the *psaos* and *pectineus* muscles, then between the *obturator externus* and the *adductor brevis*, and lastly, it appears on the gluteal region between the *quadratus femoris* and the *adductor minimus*. In this course it gives off—(a.) a series of muscular ascending branches to the *adductors brevis* and *longus*, *gracilis* and *obturator externus*; (b.) an articular branch which passes outwards beneath the *psaos* tendon, entering the hip-joint under the transverse ligament, to break up in

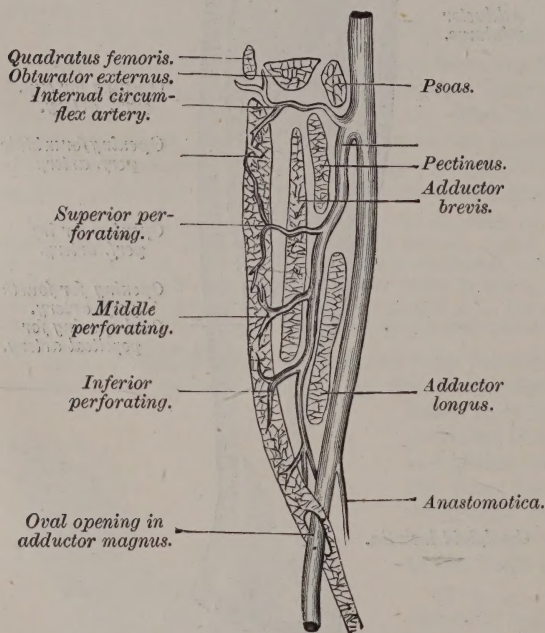


Fig. 598. — Scheme of profunda artery.

the fatty mass within; (c.) a descending branch which accompanies in part the posterior branch of the obturator nerve into the *adductor magnus*; and (d.) two terminal, one joining a branch of the sciatic artery beneath the *quadratus femoris*, and supplying the back of the hip-joint, while the other ends in the crucial anastomosis.

(3) As the profunda sinks beneath the *adductor longus*, it gives off its **first perforating** branch, which pierces backwards, close to the femur, through the *adductor brevis*, and enters the *adductor minimus*, after which it divides into an ascending branch to the crucial anastomosis, and a descending to supply the *hamstrings* and *vasti*, and to anastomose with the next.

(4) **Middle perforating artery**, larger, arises from the profunda near the lower

border of the *adductor brevis*, through which it pierces; it passes below the *adductor minimus*, and sends off an ascending and a descending anastomotic branch to the foregoing, and to the following. It also sends off in most limbs the nutrient artery to the femur, although this may be, but more rarely, a branch of the next.

(5) **Inferior perforating** arises still lower, and dips at once through the insertion of the *adductor magnus*, close to the bone, to divide into ascending and descending branches, and to nourish the short head of the *biceps* muscle.

(6) The **terminal branch** of the profunda, or fourth perforating, passes, like the others, through a tendinous archway in the *adductor magnus*, and ends in the *biceps* muscle, sending a branch downwards to anastomose with the superior internal articular branch of the popliteal artery.

(7) From the inner side of the profunda, several branches pass into the *adductor* and *semimembranosus* muscles.

354. PROFUNDA VEIN.—Each of these small arteries is accompanied by

two veins, and these ascend and ultimately unite into the one profunda vein which lies at first internal, then superficial, to its artery, finally crossing it to join the femoral vein in the angle between the femoral and profunda arteries.

The muscles in contact with the profunda suddenly become tendinous along the line of the vessel, and therefore exercise no direct pressure, but rather produce some degree of negative pressure on the vessels in their action. There are usually five pairs of valves in the profunda vein.

355. OBTURATOR NERVE.—This derivative from the anterior division of the lumbar plexus (§ 314) appears as it escapes through the obturator canal, wherein it gives off a branch to the *obturator externus* muscle and divides into its two branches. (1) Anterior obturator descends over the *adductor brevis* beneath the *pectineus* and *adductor longus*, and is distributed to these muscles (to the *pectineus* only in 8 per cent.) and to the *gracilis*. Its lowest branch is that which joins the internal cutaneous, and which supplies with it the skin on the inside of the knee. Near its origin the nerve sometimes sends an articular branch to the hip-joint.

(2) Posterior obturator usually pierces the *obturator externus*, and so is separated by the uppermost slip of that muscle from the anterior. It gives off a branch to the *adductor brevis*, a branch to the *adductor magnus*, one to the hip-joint behind the *adductor brevis*, one to the *adductor minimus*, and lastly the slender genicular or popliteal branch which descends

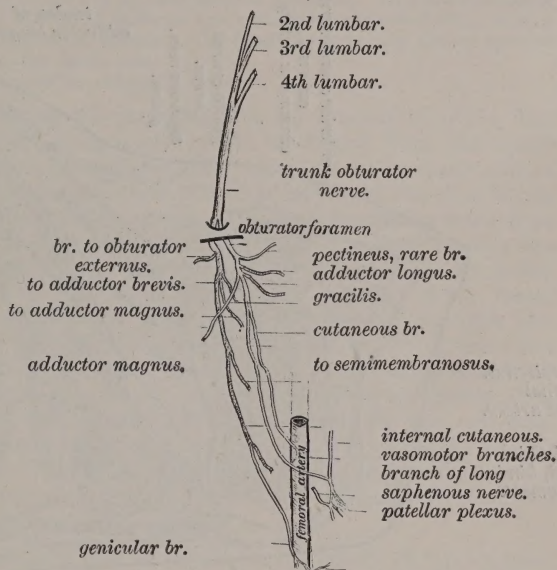


Fig. 599.—Scheme of the obturator nerve.

in the *adductor magnus* muscle to the popliteal space, getting on the dorsal surface of the artery, where it will be subsequently traced into the knee. From the nerve to the *adductor magnus* the femoral periosteal nerve arises and it sends a small twig into the nutrient foramen.

Dissection.—Divide the *pectineus* and *adductor brevis* close to their origin and reflect them outwards, and clean the surface of the *obturator externus*.

356. OBTURATOR EXTERNUS (fig. 600) widely triangular, arises in two parts—an upper smaller from the obturator crest above the obturator foramen, and a lower, much the larger, from the anterior surface of the inner half of the obturator membrane, and from the bands of fibrous tissue which overlie the vessels upon the membrane, and from the inner and under part of the bony boundary of the obturator foramen. The fibres converge to a tendon which passes horizontally backwards and outwards below the acetabulum and hip-joint to be inserted under cover of the *quadratus femoris* into the digital fossa (fig. 600).

The capsule of the hip is weak where it lies in contact with the tendon, and there are one or two bursae occasionally interposed. Its nerve, from the posterior division of the obturator (3 and 4 l.), enters the muscle on its hinder surface.

The *obturator externus* is an outward rotator, like the other adductors, in all of which the plane of the insertion is behind that of the origin. In the muscles of this series, except the *gracilis* and *obturator*, the origin and insertion planes intersect each other. As they are therefore skew muscles, the resultant is shifted a little higher on the shaft of the femur than if they were simple prismatic muscles (p. 70). The *obturator* is the highest and foremost segmentation of the adductor mass of muscle, and has no specialised representative in the upper limb.

357. THE OBTURATOR ARTERY (§ 286) from the internal iliac, having passed through the obturator canal, appears on the thigh beneath the *adductor longus*, and divides at once at its exit into two branches—(1) The outer terminal branch sends an acetabular twig, the reciprocal in size of that of the internal cir-

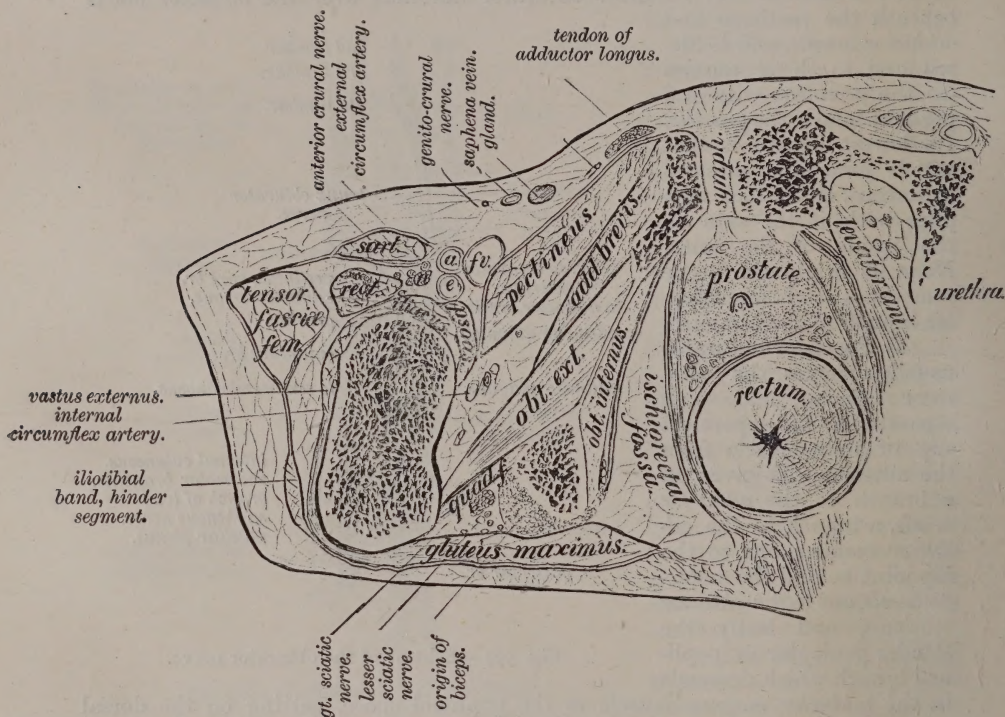


Fig. 600.—Section along the middle line of obturator externus, through pelvis and hip-joint—*fv*, femoral vein; *a*, femoral artery; *e*, profunda artery.

cumflex, and passing like it under the transverse ligament into the hip-joint; some of its branches pass through the ligamentum teres to the femur, though others form loops in the ligamentum teres and the fat at its base; the rest of this artery is lost in the *obturator externus* muscle. (2) The inner terminal branch is distributed to the *obturator externus* and the *adductors brevis* and *minimus*. A hernia has been known to escape from the abdomen through the obturator canal, and to project beneath the *pectineus* muscle.

358. FASCIA ILIACA.—If the viscera of the abdomen have been by this time dissected, the *iliacus* and *psaos* muscles can now be examined. These muscles should be examined conjointly by the dissectors of the abdomen and thigh. Covering the *iliacus* is a distinct layer of fascia, the *fascia iliaca*; this is attached above along the whole of the marginal lip of the iliac fossa, both externally along the crest and internally to the ilio-pectineal line, but it thins and becomes indistinct as it extends upwards on the front of the *psaos* muscle. When traced down towards Poupart's ligament the *fascia iliaca* is attached to the *fascia trans-*

versalis external to the femoral vessels, the union being marked by a **white line of fusion**, but as the fascia iliaca passes behind the vessels to the ilio-pectineal line the white line ceases at the femoral artery, and, as we have already seen, the fascia iliaca becomes continuous without any white line, behind the femoral vessels, with the pectineal portion of the fascia lata.

When these fasciæ are looked at from the thigh in the present advanced stage of the dissection, the space under Poupart's ligament appears consequently to be divided into two by the margin of the fascia iliaca. Externally, as the fascia lata and all other investments have been removed from the extra-abdominal part of the *iliacus* muscle, the anterior border of the line of fusion appears arching over the *iliacus* beneath Poupart's ligament, and dipping down on the inner side of the muscle. The space thus bounded is the **lacuna musculosa** of the crural arch (fig. 261). Internal to this the space traversed by the vessels (**lacuna vasculosa**) appears bounded in front by the attachment of the lower border of the transversalis fascia to the back of Poupart's ligament, behind by the iliac fascia as it becomes continuous with the pectineal, and internally by Gimbernat's ligament. The attachment of the iliac fascia prevents subfascial abscesses, such as are commonly connected with carious vertebræ, from turning towards the femoral vessels. The fascia iliaca is only a deep upward extension of a sheath derived from the fascia lata.

Remove the fascia iliaca and expose the subjacent muscles.

359. ILIACUS arises from the ilio-pectineal line, the front of the sacro-iliac and ilio-lumbar ligaments, the margin of the ala sacri and from the outer margin of the iliac fossa as far as the inferior iliac spine, from the inner side of the straight origin of the *rectus femoris*, from the deep surface of the iliac fascia, and from the margin of the anterior iliac notch. The fascicles arising from these origins fill the concavity of the iliac fossa and, converging, escape through the lacuna musculosa, whence descending backwards, they are inserted by fleshy and tendinous fibres into the rough surface below and in front of the lesser trochanter. It is covered by the fascia iliaca in the abdomen, over which lies the peritoneum, the cæcum on the right side, and the sigmoid flexure of the colon on the left. It is crossed by the external cutaneous nerve, and separated from the *psaos* internally by the anterior crural nerve. The deep circumflex iliac vessels, Poupart's ligament, the external circumflex femoral, and external branches of the anterior crural nerve lie over it, as also do the *sartorius* and *tensor fasciæ femoris* muscles. The *rectus femoris* grooves it externally and the *obturator externus* internally, the *psaos* intervening. The separation of the *psaos* from the *iliacus* is a matter of some difficulty.

The *iliacus* rests on the iliac fossa, the brim of the pelvis, the capsule of the hip-joint, and the neck of the femur. A bursa usually separates its fibres from the ilio-pubal eminence and capsular ligament, and this frequently communicates with the hip-joint. An extra-pelvic iliac slip (*ilio-capsular*) is sometimes segmented off from it externally, in like manner as the *pectineus* has become more perfectly and constantly segmented from it internally. The *iliacus* represents the *supraspinatus* of the upper limb.

360. PSOAS MAGNUS arises from the fronts of the costal processes of the lumbar vertebræ, from the edges of the bodies and intervertebral substances of the last dorsal and four upper lumbar vertebræ, and from tendinous arches stretching over the lumbar arteries opposite the side of each vertebral body. This muscle descends nearly vertically as an apparently cylindroid mass, on a plane anterior and internal to the *iliacus*, and finally ends in a tendon which lies on the brim of the pelvis and the capsule of the hip, and passes to be inserted into the lower and back part of the lesser trochanter. It is with difficulty separable from the *iliacus*.

The *psaos* is covered by a thin layer of the fascia iliaca, which is traceable to its uppermost part. Between the body of the second and the costal process of the first lumbar some of the fibres of the *diaphragm* are attached to this fascia, and they cause its border here to be strengthened into a tendinous arch, the **ligamentum arcuatum internum**. On the right *psaos* muscle lie the inferior vena cava, renal vessels, kidney, peritoneum, colon and ileo-colic artery, spermatic vessels and genito-crural nerve, the common and external iliac artery and vein; on the left lie the corresponding parts except the inferior vena cava, with the colica sinistra and sigmoid arteries in place of the ileo-colic; posteriorly it lies on the

costal processes and lumbar *intercostal* muscles, the *quadratus lumborum* muscle, and its investing fascia attached along its outer border. External to it the anterior crural nerve emerges from the lumbar plexus, which is within the muscle, and internally it touches the vertebrae, the lumbar arteries, sympathetic, genito-crural, obturator and lumbo-sacral nerves, lumbar glands, the vena cava on the right, the aorta on the left. The internal circumflex artery separates its internal border from the *pectineus* outside the pelvis.

The *psaos* and *iliacus* flex the hip-joint and rotate the thigh outwards. The *iliacus* receives three small branches from the anterior crural nerve (2 and 3 l.); the *psaos* receives four branches from the ventral branches of the four upper lumbar nerves.

361. PSOAS PARVUS, present only in 18 per cent. of bodies, lies internal to the *psaos magnus*, arising above it from the borders of the bodies of the last dorsal and first lumbar vertebrae; it ends in a flat tendon which is inserted into the most prominent part of the ilio-pectineal line, and into the iliac fascia, which it makes tense.

This muscle is constantly present, and largely developed, in leaping animals.

Abscesses connected with caries of the lumbar vertebra usually descend in the sheath of the *psaos*, and they point below Poupart's ligament.

The development of this group of muscles is obscure; the *psaos* is formed in the tissue of the somatopleure at its innermost part, directly on the dorsal side of the intermediate cell mass, and separated by a short interspace from the muscle plate. It has hence been considered as the representative of the hypaxial muscles (p. 71). Evidence is, however, wanting to prove that there is really any distinctive peculiarity in its development.

362. LUMBAR PLEXUS.—The lumbar plexus (p. 467) should now be re-examined in conjunction with the sacral plexus, as these two collectively are the homologues of the brachial plexus of the upper limb.

The ilio-hypogastric and ilio-inguinal are intercostal nerves. The external cutaneous is equivalent to the posterior superior cutaneous branch of the musculo-spiral, while the rest of the musculo-spiral is represented by the anterior crural and its lower portion by the peroneal. The obturator nerve represents the thoracics and the musculo-cutaneous. The posterior cutaneous nerve of the thigh is the homologue of the internal cutaneous, the superior gluteal of the circumflex and part of the suprascapular, while the nerves to the *iliacus* represent the rest of the suprascapular cord. The inferior gluteal is the representative of the long subscapular, and the popliteal is the equivalent of the combined median and ulnar nerves.

363. THE BACK OF THE THIGH.—Dissection.—The body being turned on its face, and the loins being raised on a block, divide the skin vertically down the middle of the back of the thigh and for the upper fourth of the leg: make a transverse incision below this and reflect the skin in two lateral flaps. Trace beneath the skin the posterior cutaneous branch of the small sciatic nerve. A superficial vein, the **superficial sural**, ascends from the outer side of the back of the leg over the calf, and dips in the middle line through a deficiency in the deep fascia to join the popliteal vein.

On removing the superficial fascia, the fascia lata is exposed, consisting superficially of strong transverse or oblique fibres over a weaker longitudinal layer, which at each side is continuous with the sheaths of the flexor muscles. Divide this fascia by a vertical incision carried along the lower fourth of the thigh and the upper fifth of the leg, and reflect it to each side, thereby exposing the popliteal space.

364. THE POPLITEAL SPACE (fig. 587) is lozenge-shaped, consisting of two triangles, an upper and lower, the base of the latter being received into that of the former. The upper triangle is bounded on the outside by the *biceps* tendon, internally by the *semimembranosus* and *semitendinosus*. The lower triangle is bounded laterally by the two heads of the *gastrocnemius* muscle. The *semitendinosus* tendon leaves the inner side of the space in the interval between the *semimembranosus* and the inner head of the *gastrocnemius* muscle (it is represented internal to the *semimembranosus* in the figure): along the outer side the peroneal nerve similarly leaves the space between the *biceps* and the outer head of the *gastrocnemius*. On the anterior and inner side of the inner boundary are the tendons of the *sartorius*, *gracilis*, and *adductor magnus*, while above and internal to the outer head of the *gastrocnemius* is the origin of the *plantaris*.

Contents.—Remove the fat from the popliteal space, and thereby bring into view the **great sciatic nerve** (*ib.* 1), dividing into its peroneal (12) and

popliteal (13) branches. On a deeper plane and traversing the space with a slight obliquity from within downwards and outwards are the **popliteal vessels** (fig. 601) emerging above from Hunter's canal through the *adductor magnus* and ending by division below. The vein lies superficial to the artery, and is closely tied to it by a firm areolar sheath; the vein above is rather to the outer side of the artery, but becomes a little internal to it below. On account of their different obliquities the nerve likewise crosses the artery as it descends, so that in this space the relations of the parts differ above, at, and below the plane of flexion of the knee. Above the knee the nerve is external, the vein intermediate, and the artery internal; below, the nerve is rather the innermost and the artery the outermost, but throughout the whole space the nerve is the most superficial and the artery the deepest (fig. 285).

The popliteal space corresponds to that portion of the ante-cubital fossa in the upper limb between the *biceps* tendon and the bicipital fascia, the former representing the *semimembranosus*, the latter the fascial insertion of the *biceps femoris*. The supinator and external epicondylar element is absent in the leg, hence the apparent contrast that in the arm the lower muscles embrace the tendons of the upper, while in the leg the upper embrace the lower. See note on gastrocnemius (p. 508).

Having seen these parts as thus related, remove the rest of the fascia from the back of the thigh and dissect the *hamstring* muscles.

365. BICEPS CRURIS arises by a *long head* tendinously from the greater sciatic ligament and the upper and inner part of the tuber ischii below the lesser sciatic notch, external to the *semitendinosus* and united to it. This head becomes fleshy, and descends, uniting about the lowest third of the thigh with the *short head* which arises fleshily from the linea aspera for about $\frac{1}{3}$ of the length of the femur, beginning below the *gluteus maximus*; it also arises from the intermuscular septum. The insertion is by a tendon into the upper and back part of the styloid process of the fibula and into the crural fascia. The fibular insertion is split by the external lateral ligament of the knee which passes through it, surrounded by a bursa.

The two heads are both somewhat penniform, especially at their union; the short head is narrow above and widens below, its lowest fascicles arising from the middle of the outer condyloid ridge of the femur and the surface adjoining. The fleshy fascicles of the muscle are only about $\frac{1}{10}$ of the length of the femur.

Two nerves from the popliteal division of the greater sciatic supply its long head above; a branch of the peroneal supplies the short head, whose vascular supply is chiefly derived from the vessels of the *vastus externus*. The biceps is covered anteriorly by *quadratus femoris*, *adductor magnus*, great sciatic nerve, external inter-muscular septum, external head of *gastrocnemius* and *plantaris*, external condyle, external lateral ligament and the external articular arteries. It is only covered behind by *gluteus maximus*, skin and fascia.

The *biceps* is a flexor of the knee, an extensor of the hip, and a rotator outwards of the foot. Its long head is nourished by perforating branches of the profunda artery.

366. SEMITENDINOSUS arises from the lower and inner part of the tuber ischii by short tendinous fibres, internal to and inseparable from the *biceps*, and soon becoming fleshy. After a short course most of the fleshy fibres are intersected by a tendinous plane, which is directed from within downwards, outwards, and backwards. This appears on the surface about half way down on the outer side, but less than a quarter of the length of the muscle from the tuber internally. The lower series of fleshy fibres soon end in a long, roundish tendon, which descends at first on the *adductor magnus*, then upon and external to the *semimembranosus* to the knee, where it passes in the groove between the latter muscle and the inner head of the *gastrocnemius*, and turning forwards is inserted into a ridge on the inner side of the tibia below the head, under cover of the *sartorius* and directly below the *gracilis*.

The upper belly is supplied by a branch of the popliteal division of the great sciatic nerve close to the origin; the lower by a second branch of the same nerve lower down. A bursa

lies beneath it and extends between the *semimembranosus* tendon and the inner head of the *gastrocnemius*. A second bursa lies beneath its tendon and that of the *gracilis* as they cross the internal lateral ligament of the knee. This muscle is a segmentation of the flexor mass not represented as a separate muscle in the upper limb in man, its upper part is a detached portion of the *biceps*.

367. SEMIMEMBRANOSUS (fig. 587) arises by a long flat tendon, which is thick-edged externally, thin-edged internally, from a long facet on the tuber ischii external and anterior to the other *hamstrings*. From the tendon short and oblique fleshy fibres arise along an oblique line, which descend from within outwards, and end internally in a tendon which extends along the inner side of the popliteal space and ends below by a threefold insertion—(1) by a tendon which passes beneath the hinder border of the internal lateral ligament into the lip of the sulcus semimembranosi on the tibia; (2) by an expansion downwards into the fascia over the *popliteus* muscle; and (3) by an expansion, the **ligamentum posticum**, which extends upwards and backwards across the back of the knee-joint to the external condyle of the femur.

The tendon of origin extends downwards for two-thirds of the thigh along its outer border; the tendon of insertion begins internally a little below the middle of the thigh. The fleshy belly is sharp internally, but most convex externally, and thickest at the lower third of the thigh.

The *semimembranosus* is covered by the two other *hamstrings*, the peculiarity of its tendon being due to its being moulded to their surface; at its insertion it is covered by the edge of the internal lateral ligament of the knee; its belly is made up of short fascicles. It lies on the *adductors minimus* and *magnus*, overlapping the popliteal vessels, from which it receives branches, and is internal to the great sciatic nerve from whose popliteal portion it is supplied. It is a flexor of the knee and a rotator inwards of the leg as well as an extensor of the hip.

The three *hamstrings* are peculiar in that they are too short to allow of full flexion of the hip while the knee is extended.

368. CONTENTS OF THE POPLITEAL SPACE.—By drawing aside the *hamstrings* the parts in the popliteal space can be more fully exposed and traced. They are:—

1. **The great sciatic nerve.**—This has already been seen (§ 327) as it emerges from the great sciatic notch and lies on the parts in the interval between the greater trochanter and the tuber ischii; it lies at first external to the *biceps*, then between its two heads, then between the *biceps* and *semimembranosus* lying on the *adductors minimus* and *magnus*. At the apex of the popliteal space, if not on a higher level, the component cords separate, the **peroneal** descending along the edge of the *biceps*, covered only by skin and fascia, and finally winding forwards round the hinder margin of the fibula, 3 cm. below the styloid process, and sinking into the *peroneus longus* muscle. The peroneal nerve before it separates from the popliteal on the back of the thigh has only given off one branch, that to the femoral head of the *biceps*; at the upper part of the popliteal space it sends off a cutaneous branch, **communicans fibularis**, which descends and becomes superficial on the calf, where it joins with the *communicans tibialis* (fig. 605, 3); a second or **external cutaneous** branch arises either with or below this, and supplies the skin on the outer side of the leg. Beneath the *biceps* tendon it sends a fine external articular branch to the outer side of the knee and to the tibio-fibular joint.

The **popliteal nerve** has already been seen (§ 327) to give off the branches to the *obturator internus*, *gemelli*, and *quadratus femoris* muscles. While it lies external to the *biceps* it gives off the upper branches to the long head of the *biceps* and to the *semitendinosus*; when it has crossed beneath the *biceps* it gives off a second branch to each of these muscles and a branch to the *semimembranosus* and one to the *adductor magnus*. Having entered the popliteal space and separated from the peroneal, it sends downwards a branch, the **communicans tibialis**, which will subsequently be seen joining with the communicating

branch of the peroneal nerve (fig. 605, 7). The popliteal nerve in the space gives off a branch on each side to the *gastrocnemius* muscle, and on the outer side a branch to the *plantaris*, and becomes below the **posterior tibial nerve** (§ 391).

369. THE POPLITEAL ARTERY is the continuation of the femoral (§§ 343, 344) through the *adductor magnus*, the opening in which can now be seen from behind. It is a tendinous passage, having the combined tendon of the *adductor magnus* and *longus* anteriorly, the *vastus internus* externally, the *great adductor* internally and behind. The only parts passing through are the artery, vein, and often the articular branch of the obturator nerve. As the artery descends outwards and a little backwards it rests on the back of the femur, the posterior ligament, the edge of the head of the tibia, and the *popliteus* muscle covered by its fascia. It lies deeply in the space, and is covered by skin and fascia, overlapped by the *semimembranosus* above and by the inner head of the *gastrocnemius* below, and terminates below the junction of the two heads of that muscle at the lower border of the *popliteus* muscle by dividing into anterior and posterior tibial arteries. The termination cannot yet be seen (fig. 601).

The **popliteal vein** lies superficial to its artery and crosses it obliquely, being tightly tied to it by its sheath and receiving a branch corresponding to each branch of the popliteal artery, as well as the sural vein. It has two valves near its lower end below the level of the knee, and one above, close to the opening in the *adductor magnus* muscle.

The **genicular branch** of the obturator nerve descends on the posterior (superficial) aspect of the artery to the knee-joint, which it enters through a hole in the posterior ligament.

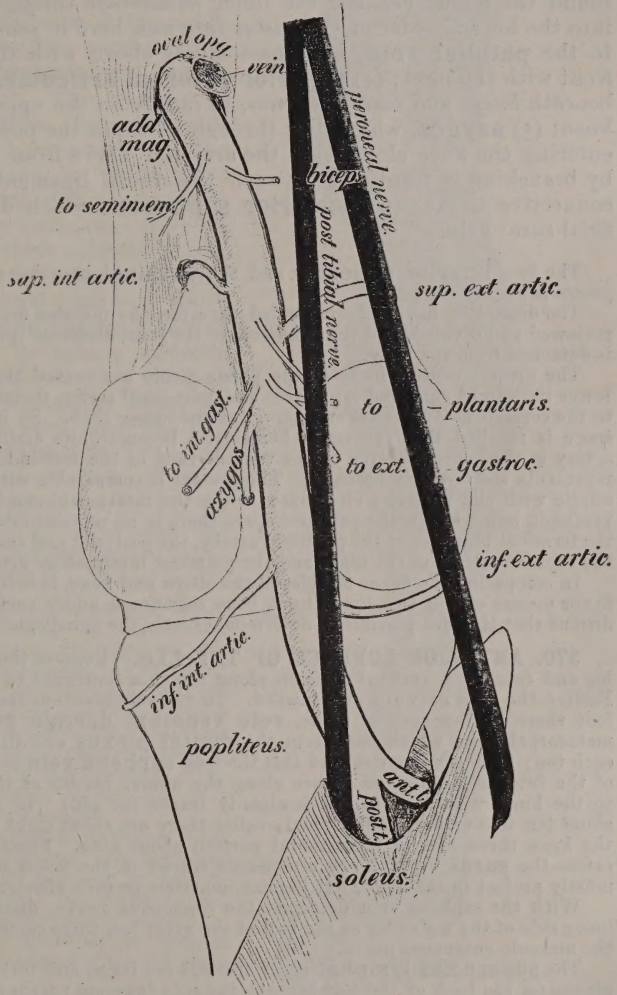


Fig. 601.—Scheme of the right popliteal artery.

Five small lymphatic glands lie embedded in the fat beneath the popliteal artery, and receive the deep lymphatics of the leg. They communicate with the large, loose lymphatic plexus which lies at the back of the knee between the condyles. Their efferent vessels enter Hunter's canal.

The branches of the popliteal artery are—(1) two or three **muscular** branches to the *hamstrings* (fig. 601); (2) two **sural** branches, outer and inner, to the muscles of the calf; (3) a **superior internal articular**, which winds round the femur beneath the inner *hamstrings* through the *adductor magnus* into the lower border of the *vastus internus*, here it sends branches downwards to the **patellar rete**, but anastomoses above with the anastomotica and in front with the next; (4) **superior external articular**, which passes outwards beneath *biceps* and *vastus externus*, to ramify on the upper and outer part of the knee; (5) **azygos**, which dips through a hole in the posterior ligament, thereby entering the knee along with the articular nerve from the obturator. It ends by branching in front and between the crucial ligaments in the intra-articular connective tissue; (6) **posterior saphenous** which descends with the superficial sural vein.

The two **inferior articular** and the **terminal** branches cannot yet be seen until the *gastrocnemii* are dissected.

The dissection having been carried thus far, the muscles around the hip-joint are to be reviewed and divided, and the ligaments of the joint dissected (p. 177); by so doing the limb is detached from the body.

The greater ventral fixity of the pelvic girdle has caused the vessels and nerves of the lower limb to be sundered into a pre- and post-zonal series, thereby obscuring their relations to the corresponding vessels and nerves of the upper limb. So it is not until the popliteal space is reached that the serial homologies become quite easily recognised. The femoral artery is the representative of the *vas aberrans* of the forelimb, and the *profunda femoris* represents the ordinary brachial. The gluteal is comparable with the subscapular, and the sciatic with the posterior circumflex, while the internal circumflex represents the superior *profunda humeri*. In the popliteal space there is no representative of the radial artery, and the terminal branches of the popliteal artery, the posterior and anterior tibial, are respectively the representatives of the ulnar and the posterior interosseous artery.

In comparing the flexor muscles of the elbow and knee, it is to be noted that the common flexor masses of the two limbs have been segmented under such different mechanical conditions that it is not possible to determine exactly the homologies of the several segments.

370. ANTERIOR SURFACE OF THE LEG.—Remove the skin from the front of the leg and foot by a vertical incision along the shin continued to the base of the second toe. Reflect the flaps outward and inward. In the subcutaneous fascia over the dorsum of the foot there lies an arch of veins, **rete venosum dorsale pedis**, receiving a series of metacarpal veins which arise from the **digital plexus** and **digital arch** on the back of each toe; from the inner side of this the long **saphena vein** is continued upwards in front of the internal ankle, and passes along the hinder border of the subcutaneous tibial area to the knee, whence it has been already traced (p. 480). In the pedal veins, valves are about ten in number, in the tibial region there are about eight valves, at the inner side of the knee three, and in the femoral portion about nine. From the outer side of this arch arises the **sural vein**, to be afterwards traced in the fascia of the calf. The valves are mostly perfect in the child, but become imperfect or even obsolete in old age.

With the saphena vein descends the saphenous nerve, distributed to the skin on the inner side of the leg as far as the ball of the great toe, there communicating with a branch of the musculo-cutaneous nerve.

The **superficial lymphatics** of the legs are large, and form a very large, close-meshed plexus on the back of the foot beneath the rete venosum; from this and from the outer side of the leg numerous many-valved lymphatic vessels pass upwards and inwards, streaming over the surface of the tibia to the vicinity of the saphena vein, along with which they ascend to the knee.

371. THE DEEP FASCIA over the extensor muscles is attached internally to the crest of the tibia and to the front of the malleolus, above to the outer edge of the head of the tibia, and externally to the anterior ridge of the fibula. It is strong above where it receives fibres from the *vastus externus*, ilio-tibial ligament, and *biceps*. The superficial fibres run downwards and inwards, and

the underlying muscles arise from it. In the middle of the leg this fascia thins, but below, the fascia again becomes strong, on account of the permanent hyper-extension of the ankle-joint, as it has to bear the strain of the extensor tendons which work within sheaths of it as in so many pulleys. Above the malleoli these fibres become strong and form a nearly transverse flat band, the **superior anterior annular ligament**; below this there is a weak area, but at the flexion of the ankle the fascia over the tendon appears as a λ-shaped band, the **ligamentum lambdoideum** (fig. 602, 12). The long leg of the lambda stretches from the inner malleolus downwards and outwards to the calcaneum, and the short leg starts from the middle of this and dips downwards and inwards to the navicular and internal cuneiform bones. The three radiating parts, however, differ from each other in arrangement of fibres, the external portion is really a loop (**ligamentum fundiforme**) attached to the calcaneum and projecting upwards and inwards, and through this loop the *long extensor* tendons of the toes pass. From the inner extremity of the loop pass the two inner bands, one upwards to the tibia, one downwards to the navicular. Beneath these there are two sheaths separated from each other by a partition, the inner for the *tibialis anticus* (ib., 2), a second for the *extensor hallucis* (ib., 3) and the vessels and nerve.

The bursa lining the sheath from the *tibialis anticus* extends upwards as far as the superior band of the annular ligament; the bursa for the *extensor hallucis* only extends under the lambdoid ligament, the deep wall of the bursa separating the tendon from the anterior tibial vessels and nerves which here pass beneath the ligament; the bursa for the other extensor tendons lines the loop of the calcanean attachment of the ligament. The sheath for the *tibialis anticus* is included in a splitting of the fibres of the ligament.

Below the annular ligaments there are two thin layers of fasciæ on the dorsum of the foot—one weak, overlying the tendons and lost in the subcutaneous tissue of the toes; the other deeper, overlying the *interossei* beneath the extensors.

Divide and remove the fascia on the front of the leg, leaving the annular ligaments, and clean the subjacent muscles.

372. TIBIALIS ANTICUS (fig. 602, 1), somewhat prismatic, arises from the lower part of the outer surface of the head of the tibia, and from the upper two-thirds of the outer side of its shaft, from the fascia which covers it, and from the tibial edge of the interosseous membrane. A thin septum of fascia dips in between it and the *extensor digitorum longus*, from which also a few fibres arise. The fibres converge to a flattish tendon which begins on the front of the muscle,

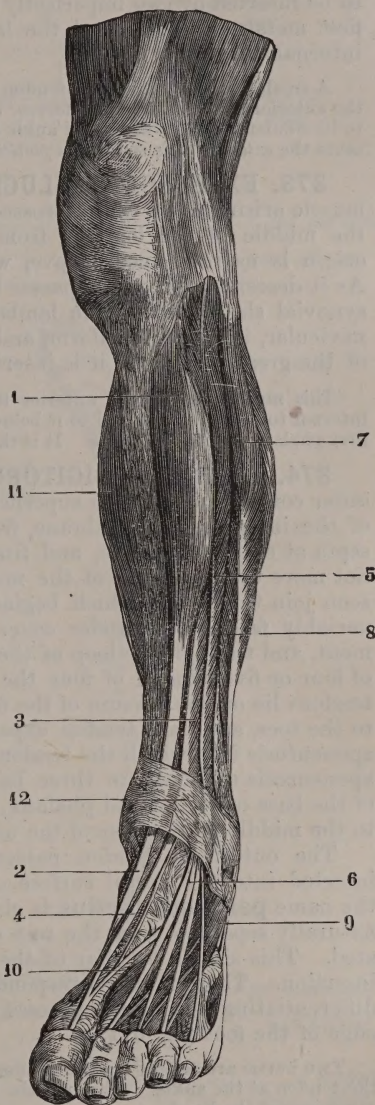


Fig. 602.—Muscles on the front of the leg—11, gastrocnemius; 5, 6, extensor digitorum longus; 7, 8, peronei; 9, extensor brevis digitorum.

descends over the anterior surface of the tibia, through the innermost sheath in the annular ligament, and surrounded by a long cylindroidal synovial bursa. It crosses the ankle, astragalus, navicular, and internal cuneiform bones to be inserted by two imperfectly separated slips, the smaller into the base of the first metatarsal bone, and the larger into the front of the inner side of the internal cuneiform (*ib.*, 2).

A small bursa underlies its tendon as it glides on the internal cuneiform bone. It has the anterior tibial vessels and nerves, the *extensor longus digitorum*, and the *extensor hallucis* to its fibular side. It flexes the ankle and everts the foot, tending to supinate it. It represents the *extensor ossis metacarpi pollicis* of the hand.

373. EXTENSOR HALLUCIS LONGUS (fig. 602, 3, 4) is a penniform muscle arising from the interosseous margin of the fibula for half its length in the middle of the leg, and from the interosseous membrane beside it. The origin is narrow, linear above, wider from the interosseous membrane below. As it descends, its tendon passes beneath the annular ligament, having a short synovial sheath under the lambdoid ligament; it lies on the ankle, astragalus, navicular, internal cuneiform, and first metatarsal, passing to the dorsal surface of the great toe, where it is inserted into the base of the second phalanx.

This muscle crosses the anterior tibial vessels near the flexure of the ankle, these lie internal to it above, external to it below. It usually sends an expansion into the base of the first phalanx on its inner side. It is the equivalent of the *extensor pollicis major* of the hand.

374. EXTENSOR DIGITORUM LONGUS (fig. 602, 5, 6) arises from the outer condyle of the tibia superficial to the *tibialis anticus*, from the upper sixth of the interosseous membrane, from the fascia over it, from the intermuscular septa at each side above, and from the narrow anterior surface of the fibula; not more than one-fifth of the muscle, however, has a bony origin. Its fibres soon join the tendon which begins on its anterior surface, and which descends, variably fasciculated under cover of the transverse part of the annular ligament, and through the loop of the lambdoid ligament; here the tendon consists of four or five slips, if of four the innermost here divides into two, so that five tendons lie on the dorsum of the foot, of these the four innermost pass forwards to the toes, and each tendon expands on the back of the first phalanx into an aponeurosis into which the tendon of the *extensor brevis* is inserted. This dorsal aponeurosis divides into three bands distally, a central attached to the middle of the base of the second phalanx, and two lateral which converge downwards to the middle of the base of the ungual phalanx (fig. 611, 3).

The outermost tendon passes forwards and outwards expanding to be inserted into the dorsal surface of the base of the fifth metatarsal, and to it the name **peroneus tertius** is given. The fleshy belly attached thereto is not naturally separable from the rest of the extensor, and is not separately innervated. This slip is peculiar to the human leg, and varies a little in its range of insertion. There is no corresponding slip in the forelimb, and it seems to be a differentiating slip in the process of specialisation for the raising of the outer edge of the foot (fig. 611, 4).

Two bursæ are related to the tendon of this muscle, one overlying, the other underlying the tendon at the ankle. This muscle is serially homologous with the *extensor digitorum communis* of the hand.

375. PERONEAL NERVE.—These muscles are supplied by branches of the peroneal nerve (p. 498), which has been traced to the back of the fibula (fig. 603, 1), and which divides into its two terminal branches, **musculo-cutaneous** and **anterior tibial**, as it traverses the *peroneus longus*. The outer or musculo-cutaneous (*ib.*, 3, 4) descends through the *peroneus longus* and *brevis*, pierces the deep fascia at the outer side of the *extensor longus digitorum* in the middle third of the leg, dividing in the superficial fascia into

inner and outer branches as it does so. Sometimes the division is subfascial, and then the inner larger branch escapes a little above the outer.

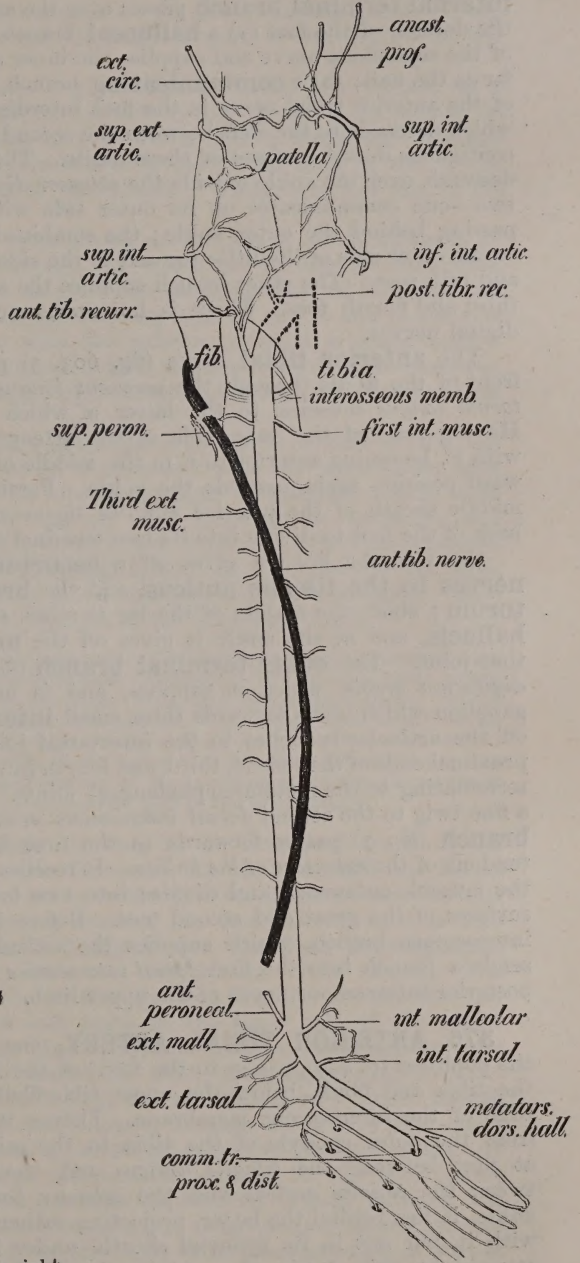
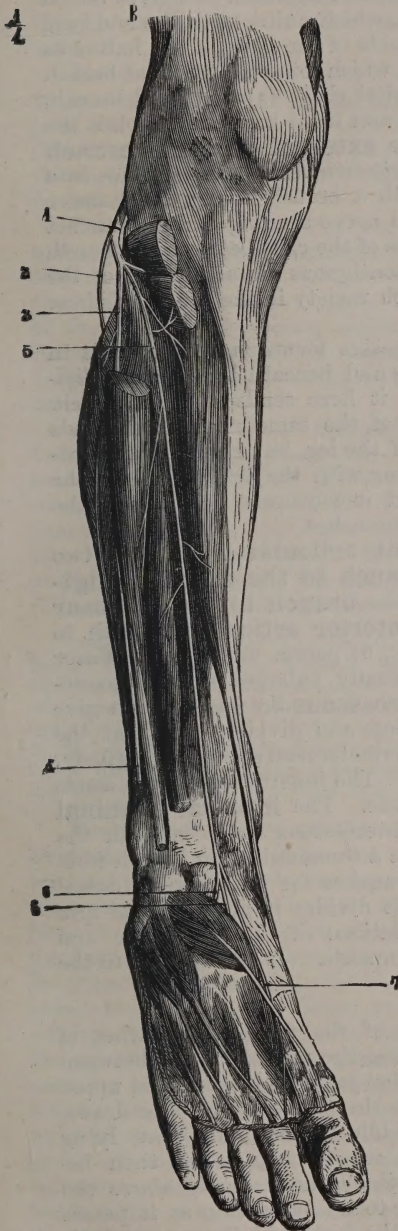


Fig. 603.—Course and distribution of the right peroneal nerve—1, peroneal nerve; 2, external cutaneous branch; 3, 4, musculo-cutaneous; 5, 6, 7, branches of anterior tibial nerve.

Fig. 604.—Scheme of the articular rete of the knee and of the course and branches of the right anterior tibial artery.

Before its division the musculo-cutaneous nerve gives off two branches to the *peroneus longus*, superior and inferior; and one to the *peroneus brevis*. Its **internal terminal branch** passes over the annular ligament and gives off on the dorsum of the foot (1) a **halluceal** branch, which unites with the end-twig of the saphenous nerve and supplies the inner side of the back of the hallux as far as the nail; (2) a **communicating** branch, which joins the terminal branch of the anterior tibial nerve in the first interdigital cleft; (3) a **lateral** branch, which descends to the cleft between the second and third toes and supplies the contiguous dorsal surfaces of these digits. The **external terminal branch** descends over the ankle outside the *extensor digitorum* tendon and divides into two—one communicates on its outer side with a branch of the sural nerve passing behind the outer ankle; the combined nerve sending digital branches to the outer side of the little toe and to the sides of the cleft between the fourth and fifth toes. The other branch supplies the contiguous dorsal surfaces of the third and fourth toes. There is, however, much variety in the course of these digital nerves.

The **anterior tibial nerve** (fig. 603, 5) passes forwards and inwards in front of the fibula through the *peroneus longus* and beneath the *extensor digitorum longus* muscles, to the latter of which it here sends a small branch. Having reached the outer side of the artery of the same name it descends with it, becoming anterior to it in the middle of the leg, but resuming its outward position again towards the ankle. Passing with the artery beneath the middle sheath of the anterior annular ligament it continues forwards on the back of the foot to divide into its two terminal branches.

Close to the knee it gives off a **recurrent articular** branch and two **nerves to the tibialis anticus**, and the **branch to the extensor digitorum**; about the middle of the leg it sends the **branch to the extensor hallucis**, and at the ankle it gives off the **anterior articular branch** to that joint. The **outer terminal branch** (*ib.*, 6) passes under the *extensor digitorum brevis*, which it supplies, and is usually enlarged into a pseudoganglion which sends forwards three small **interosseous** branches, which give off the articular branches to the intertarsal joints and divide into two at the proximal ends of the second, third, and fourth intermetatarsal spaces respectively, terminating in the metatarso-phalangeal joints. The innermost of these sends a fine twig to the second *dorsal interosseous* muscle. The **internal terminal branch** (*ib.*, 7) passes forwards to the first interosseous space beneath the tendons of the *extensors of the hallux*. It receives a communicating branch from the musculo-cutaneous, and divides into two branches for the opposed dorsal surfaces of the great and second toes. Before it divides it gives off the first interosseous branch, which supplies the articulations of the first space and sends a branch into the first *dorsal interosseous* muscle. It corresponds to the posterior interosseous nerve of the upper limb.

376. ANTERIOR TIBIAL ARTERY, one of the terminal branches of the popliteal (p. 499), passes to the front of the leg through the space between the tibia and fibula, below the upper tibio-fibular joint and above the upper edge of the interosseous membrane. Thence it descends along a line drawn from the outer condyle of the tibia to the middle of the ankle-joint, lying at first between the *tibialis anticus* and the *extensor digitorum*, then between the *tibialis anticus* and the *extensor hallucis*, and, shortly above the ankle, it lies behind the latter, projecting rather to its outer side as it passes with it, but not in its synovial sheath, under the lambdoid ligament. It is covered by skin, fascia, the annular ligament, and the muscles on each side which overlap it, crossed by the *extensor hallucis* and by its nerve, which, however, is external to it both above and below. It is accompanied by two veins

which are joined together by many cross branches. The artery and veins are tied to the front of the interosseous membrane by a series of areolar bands, but do not lie in a regular canal of the membrane; for the lower fourth of the leg they lie on the front of the tibia and the anterior part of the capsule of the ankle.

Before it reaches the front of the leg the anterior tibial artery gives off a **recurrent posterior branch**, which ascends behind the *popliteus* muscle to join the inferior external articular artery above, and a **superior fibular** (fig. 604, *sup. peron.*), which passes transversely round the neck of the fibula, through the *peroneus longus* ending in that muscle. These branches cannot yet be seen.

On emerging in front of the interosseous membrane it sends upwards an **anterior recurrent branch** through the origin of the *extensor digitorum*, continuing upwards in the groove between the outer condyle of the tibia and the head of the fibula to supply the surrounding muscles and to end in the rete of the knee, anastomosing chiefly with the inferior external articular artery. A large branch, sometimes separate in origin, descends between the *extensor hallucis* and the *extensor digitorum*, which below anastomoses with the peroneal artery.

About twelve small **muscular arteries** arise on each side of the anterior tibial artery, which run nearly transversely into the muscles on each side. Above the ankle there arise two **malleolar branches**, which wind round the ankles beneath all the tendons. The **external** is the larger, and passes to the rete on the outer ankle formed by it with a branch of the external tarsal and of the peroneal. The **internal** forms a similar rete over the inner ankle, with branches of the posterior tibial and internal tarsal arteries. Both retia send off nutrient and articular arteries to the bones and joint.

Close to the origin of the external malleolar, the tibial artery receives a communicating branch from the peroneal through the interosseous membrane. The anterior tibial artery represents the posterior interosseous of the upper limb, and this communicating branch resembles the posterior branch of the anterior interosseous. The trunk radial artery has no equivalent in the leg, so the next artery which corresponds to the post-carpal continuation of the radial appears as the continued trunk of the anterior tibial; the continuity being due to the dilatation into a trunk of the representatives of the anastomosis between the posterior interosseous, the posterior carpal, and the post-carpal part of the radial artery.

The **dorsal artery of the foot** (fig. 604) is the continued trunk of the anterior tibial artery from the ankle forwards. It runs beneath the dorsal tendons, appearing in the interspace between the tendons of the *extensor hallucis longus* and the *extensor brevis*. Having reached the first interspace it divides into its terminal branches, **dorsalis hallucis** and the **first interosseous perforating**. The nerve lies to its outer side for its whole extent. The branches of the dorsalis pedis before its final division are—(1) several internal tarsal branches to the bones and soft parts on the inner side of the ankle, joining the internal malleolar rete above; (2) one external tarsal arising over the navicular and arching outwards under the short extensor, making with the next an extensive dorsal arterial rete; (3) the metatarsal is a larger branch which passes outwards under the *short extensor*, forming an arch which externally terminates by anastomosing with the branches of the external tarsal. It gives off from its distal side three interosseous arteries to the three outer interspaces, each of which sends a posterior perforating branch between the heads of the *dorsal interosseous* muscle to join the deep plantar artery; at the distal end of the metatarsals each divides into three branches, one of which, the anterior perforating, passes to the plantar surface to join the plantar digital vessels; the others supply the opposed sides of the digital clefts on the dorsal side. The outermost branch of the metatarsal supplies the outside of the little toe.

The **dorsalis hallucis** descends in the first interosseous space, and resembles, but on a larger scale, the other interosseous vessels. The **first interosseous perforating**, similarly, is like, but larger than, the perforating branches in the outer spaces, and in the sole it anastomoses with the terminal branch of the deep plantar arch. It represents the perforating portion of the radial artery in the upper limb.

377. SHORT EXTENSOR MUSCLES.—On the back of the foot beneath the long tendons, but over the vessels, there are two closely connected muscles, which should be examined next.

(1) **Extensor hallucis brevis** (fig. 603) arises by two heads, one from a tubercle on the calcaneum near the mouth of the sinus tarsi, the other from the deep process of the loop of the lambdoid ligament (*ligamentum fundiforme*); descending obliquely inwards, its tendon crosses the *dorsalis pedis* artery, and is inserted into the base of the first phalanx of the great toe. It is but little, or not at all, connected with the tendon of the *long extensor*.

Extensor brevis digitorum arises by several vertical tendinous lamellæ from the calcaneum between the two attachments of the loop of the lambdoid ligament and from the neighbouring border of the cuboid bone. The muscle divides into three slender fleshy bellies whose tendons are inserted into the dorsal aponeurosis of the second, third, and fourth toes respectively, uniting with the tendons of the *long extensor*. The corresponding muscles in the upper limb are only represented by rudimental slips, of which that for the ring finger is the most frequently present.

378. THE BACK OF THE LEG AND SOLE OF THE FOOT.—These regions are so closely connected that they should be examined together, for which purpose the limb should be placed on its extensor aspect and the skin divided by a vertical incision from the popliteal space to the heel and by a cross cut from one malleolus to the other, across the back of the heel; reflect the two lateral flaps. Beneath the skin on the calf the **sural vein** can be traced, beginning below at the outer limb of the rete venosum dorsale (p. 500), and ascending behind the outer ankle and along the middle of the calf to open into the popliteal vein (p. 499). In this vein there are eight valves; a small superficial sural branch of the popliteal artery accompanies it.

The cutaneous nerves of the calf are—(1) the external cutaneous of the peroneal (p. 498) and the two communicantes (p. 498). These unite at a variable distance down the back of the leg and form the **superficial sural nerve** which supplies the skin over the calf to the heel, and whose terminal branch winds forwards beneath the outer ankle to join the musculocutaneous nerve (p. 502). Beneath the skin of the back of the heel and over the insertion of the tendo Achillis there is, not uncommonly, a subcutaneous bursa.

379. THE DEEP FASCIA of the calf is the continuation downwards of that of the popliteal space, and is strengthened externally by its attachment to the head of the fibula and by fibres from the *biceps* tendon. Internally it is attached to the edge of the tibia, over the inner side of which the fascia is strengthened by fibres from the *sartorius*, *gracilis*, and *semitendinosus* tendons. At the lower half of the leg a deep process of the fascia dips in beneath the superficial muscles of the calf (fig. 606, 16), covering the deep flexor muscles; these two layers remain partly separable at the ankle; the fascia of the calf, however, becomes thinner, while that over the deep muscles here thickens into an internal annular ligament. This stretches from the inner side of the calcaneum to the back of the inner ankle and the navicular bone. It is split close to the ankle to form a sheath transmitting the *tibialis posticus* tendon, external to which in a separate sheath passes the *flexor digitorum* tendon. In a superficial sheath at a different level pass the posterior tibial vessels and nerves, and at its outermost part, where it is attached to the calcaneum, the *flexor hallucis* passes beneath it. The lower border of the ligament is continuous into the inner part of the plantar fascia.

Externally, an intermuscular septum dips between the *soleus* and deep flexors behind and the *peronei* externally, and, at the lower border of this

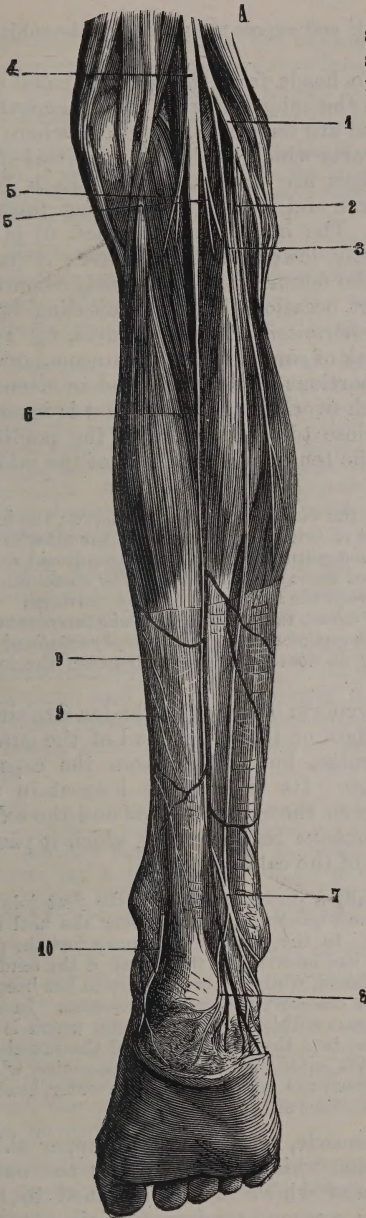


Fig. 605.—Superficial dissection of the muscles and nerves of the left calf—1, peroneal nerve; 2, its external cutaneous branch; 3, communicans fibularis; 4, popliteal nerve; 5, branches to the gastrocnemius; 6, communicans tibialis; 7, union of communicantes to form the posterior saphenous nerve; 8, calcanean branch; 9, sural cutaneous branches of internal saphenous nerve; 10, posterior tibial nerve.

septum, the fascia over the *peronei* becomes strengthened into an external annular ligament under which the *peronei* descend.

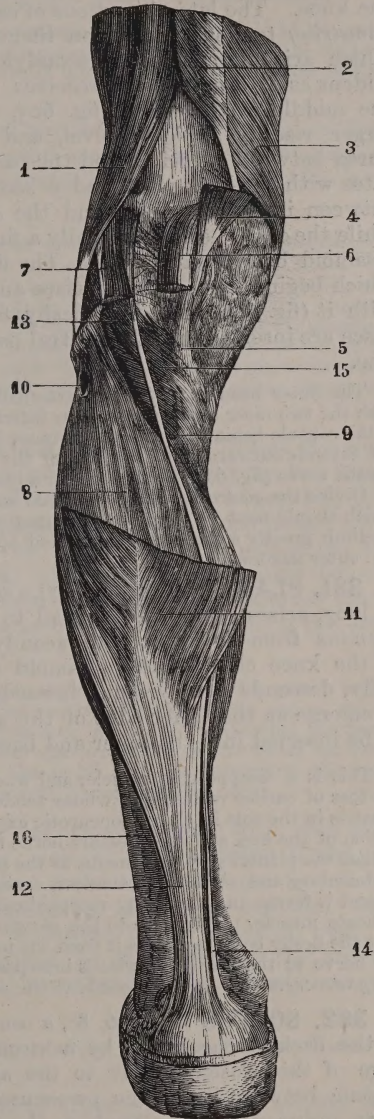


Fig. 606.—Second layer of muscles of the left calf—1, biceps; 2, semitendinosus; 3, vastus internus; 4, semimembranosus; 5, its fascial insertion; 6, inner head of gastrocnemius; 7, plantaris; 8, soleus; 9, popliteus; 10, bursa; 11, gastrocnemius; 12, tendo Achillis; 13, popliteus; 14, plantaris tendon; 15, fascia over popliteus; 16, deep tibial fascia.

Dissection.—Remove this fascia from the calf and expose the surface of the subjacent muscle and tendon.

380. GASTROCNEMIUS arises by two heads from the gastrocnemial area above each condyle of the femur and from the subjacent part of the capsule of the knee. The lateral portions of each head are tendinous, especially where the *hamstring* tendons bear upon them, the parts which border the popliteal space which arise from the supracondyloid ridges are mostly fleshy. Each head widens as it descends and receives its nerve and vessel on the aspect towards the middle of the space (fig. 605, 5, 5). The inner head (fig. 606, 6) is the larger, rises to a higher level, and is fleshy lower down the outer; it has a bursa between its origin and the back of the femur which frequently communicates with the knee-joint, and a second but occasionally communicating bursa between its inner border and the *semimembranosus* (Brodie's bursa, fig. 277), while the outer head has usually a fine streak of cartilage and not uncommonly a sesamoid bone in its origin. The fleshy portions on each side end in a tendon which begins on the deep surface and which overlaps the *soleus*, and is inserted with it (fig. 606, 11). The fleshy fibres close to the borders of the popliteal space are inserted into the central part of the tendon on each side of the middle line.

The outer head is in contact externally with the *biceps* and peroneal nerve; the inner with the two *inner hamstrings*. The inferior limit of origin on each side is the attachment of the capsule behind the knee; the inner head is not restricted to the supracondyloid ridge, but extends outwards into the floor of the popliteal space external to it. The communicans tibialis nerve (fig. 605, 6) often lies in a canal between the two heads as they converge.

Divide the *gastrocnemius* at its union with the *soleus*, taking care to avoid the *plantaris*, which should next be cleaned. The *gastrocnemius* represents the *flecor carpi radialis* of the forelimb greatly expanded and divided and lying, as does that muscle, between the inner and outer flexors.

381. PLANTARIS (fig. 606, 7), a small pyriform belly with a tendon five times as long, arises above and internal to the origin of the outer head of the *gastrocnemius* from the outer supracondyloid ridge, but chiefly from the capsule of the knee close to the sesamoid cartilage. Its tendon, the longest in the body, descends from without inwards between the *gastrocnemius* and the *soleus* to emerge at the inner edge of the *gastrocnemius* tendon along which it passes to be inserted into the inner and back-part of the calcaneum.

This is a disappearing muscle, and was originally a perforate flexor of the first joint of the toes of earlier vertebrates, whose tendon in most quadrupeds passes over the heel and expands in the sole into an aponeurotic expansion. In the plantigrade human foot the projection of the heel and the pressure borne thereon has interrupted the course of the tendon, so that the plantar portion remains as the plantar fascia, while the crural portion has become rudimentary and almost functionless, except as an accessory to the *gastrocnemius*. In this respect it forms an interesting morphological contrast with the *peroneus tertius* which is an inchoate muscle. The nerve to the *plantaris* passes into the deep surface of the muscle so that the fleshy belly separates it from the nerve to the outer head of the *gastrocnemius*, while the nerve to the *soleus* likewise is interposed between the *plantaris* and the outer head of the *gastrocnemius*. It corresponds to the *palmaris longus* of the upper limb.

382. SOLEUS (fig. 606, 8), a complex muscle, arises from the upper third of the back of the fibula by a strong tendon which extends along the outer edge of the muscle nearly to the ankle, and which is also attached to the septum between it and the *peroneus longus*; a second tendon of origin extends as an archway from the fibula to the tibia, crossing the tibial vessels and nerve; and a third tendon, the smallest, arises from the oblique line on the tibia below the *popliteus* muscle extending some way along the inner margin of the tibia. The fleshy fascicles are short and oblique, and pass in various sets to a flat tendon of insertion which begins on the superficial aspect, at first as a series of vertical streaks very near the knee, and these coalescing, form a thickening and narrowing tendinous plane, but appearing on the surface only as a median

stripe into whose surface the tendon of the *gastrocnemius* is inserted. As this approaches the ankle it narrows into a stout cord, the tendo Achillis (fig. 606, 12), the strongest tendon in the body, about 11 cm. long by 2 broad and 6 mm. thick, and is inserted into the lower and back part of the calcaneum.

The fibres from the fibular tendon diverge bipenniformly, the outer going to the outer margin of the tendon of insertion, the inner to its deep surface and to the median stripe of the tendon. The fibres from the arch descend vertically into the deep surface of the tendon. The tibial origin is also bipenniform.

The tendo Achillis glides over the upper part of the back of the heel from which it is separated by a bursa, whose synovial membrane is villous along its margin; both the tendon and the heel are coated at this place by a thin layer of fibro-cartilage to diminish friction.

These great muscles of the calf are large muscles with short fascicles, and are capable of powerful contraction. They act as extensors of the ankle and as flexors of the knee. The *soleus* receives two nerves, one from the popliteal arising close to the nerve for the outer head of the *gastrocnemius*, and one arising lower down and running obliquely to the deep plane of fibres arising from the tendinous arch. The tibial head of the *soleus* is secondary in origin, and is almost peculiar to man being only occasionally present in one or two of the anthropoids. The muscle is represented in the upper limb by the ulnar origin of the *flexor sublimis digitorum*, which has here become fused with the representative of the *flexor carpi radialis* at its insertion.

383. TERMINATION OF THE POPLITEAL ARTERY.—Divide the tendo Achillis and remove the *gastrocnemius* and *soleus* muscles, thereby the two lowest branches and the termination of the **popliteal artery** are exposed (§ 369). These are—(7) the **inferior internal articular** (fig. 604) which passes under the internal lateral ligament of the knee to the lower and inner part of the rete articulare, and (8) the **inferior external articular** which passes beneath the outer head of the *gastrocnemius*, the *biceps* tendon, and the external lateral ligament, and over the *popliteus* tendon to terminate in the rete on the outer side.

The rete articulare forms a large network of vessels around and over the patella and on the contiguous ends of the femur and tibia. The vessels which form this plexus are the four articular branches of the popliteal, the descending branch of the external circumflex femoral, the terminal branch of the profunda, the anastomotica and the tibial recurrent. The largest vessels to the patella enter it from above, hence pads pressing on the upper edge of this bone in cases of fracture may interfere with its nutrition (fig. 604).

The two terminal branches of the popliteal artery separate from each other at the lower border of the *popliteus* muscle; one (9), the **anterior tibial**, can now be seen as it passes forwards, and its two earliest branches can be followed (p. 505). The second terminal branch, **posterior tibial**, is hereafter to be traced down the back of the leg. The formation of the popliteal vein, by the convergence of three veins, each formed by the union of the anterior tibial, the posterior tibial, and the peroneal venæ comites respectively, can now also be seen.

Raise the popliteal artery and divide the *biceps* tendon. Remove also the fascia over the *popliteus* muscle and clean its surface.

384. POPLITEUS (figs. 606, 15; 608, 6) arises by a strong tendon from the lower and front part of the popliteal groove in the outer condyle of the femur. The tendon descends backwards over the articular margin of the outer condyle when the knee is extended, but it lies in the popliteal sulcus when the knee is flexed; it crosses and grooves the outer edge of the outer semilunar cartilage in the knee and lies beneath the *biceps* tendon, the external lateral ligament and the inferior external articular artery. The tendon gives rise to diverging fleshy fascicles forming a wide triangular muscle which is

inserted into the triangular surface on the tibia between the soleal line, the infraglenoid margin, and the edge of the internal lateral ligament.

The extreme fibres of this muscle form with each other an angle of about 40° , and are of very variable lengths.

The *popliteus* acts as a flexor and pronator of the leg. Its nerve, from the popliteal, enters its lower and anterior margin. It represents the *pronator teres* of the upper limb.

385. SUPERFICIAL DISSECTION OF THE SOLE.—Previous to dissecting the deep flexor muscles of the leg, divide the skin of the sole of the foot from the heel to the base of the second toe, and by a second incision across the bases of the toes. The reflection of the flaps of skin is a matter of some difficulty, as the subjacent plantar fascia is tied to the skin, especially at the bases of the toes, by many strong fibres. Beneath the skin is a quantity of granular fat surrounded by tough septa of areolar tissue; when this fat is carefully removed, especially towards the heel, the terminal filaments of the internal calcanean nerves are seen perforating the annular ligament and passing to the skin of the heel. Farther forwards towards the toes, when the fat is removed from the interdigital spaces, the digital nerves and vessels appear passing to the sides of the toes under bridging bands of the deep fascia, hence the removal of the fat must be warily, but should be thoroughly, accomplished.

The **plantar fascia** is twofold. There is a general deep fascia of very varying thickness enveloping the muscles of the sole, but in the middle this has become specially developed and strengthened, having worked up into it what was originally the plantar portion of the tendon of the *plantaris*. This **central portion** is glistening white, and consists chiefly of longitudinal fibres attached behind to the edge of the internal tubercle of the calcaneum. As it passes forwards it widens and thins, and the number of transverse fibres increases. On reaching the heads of the metatarsal bones it divides into five slips, each of which expands and divides into two strata—superficial and deep. The chief superficial layer is inserted into the skin along the deepest part of the pre-digital sulcus, while the deeper part divides into two lateral bands, which are lost in the capsular ligaments of the metatarso-phalangeal joints and sheaths of the flexor tendons. The cross fibres here appear very strong and distinct, binding these slips together, and forming bridges across the digital nerves and vessels.

Along the side of this middle portion of the plantar fascia are two **lateral intermuscular septa**, which dip in along the lines of the furrows which, when the fat is removed, limit the margins of the middle area; these septa are strongly marked behind, but become weaker and more interrupted in front. They separate the muscles of the hallux and little finger respectively from those of the middle area.

The fasciæ of the lateral area of the sole are continuous with those of the back of the leg, and form sheaths respectively for the muscles of the hallux and little toe. The inner is the weaker; the outer becomes strengthened along a line joining the outer side of the fifth metatarsal spur and the calcaneum. This strengthened band, the **ligament of the fifth metatarsal**, often exhibits fleshy fibres, and forms an outermost muscle in the sole, the *abductor ossis metatarsi minimi digiti*.

Dissection.—Divide the middle portion of the plantar fascia transversely about 8 cm. in front of the heel, and remove it, dissecting the two flaps respectively forward and backward, avoiding injury to the underlying internal plantar nerve. The fascia must be carefully detached from the underlying muscle, as this takes origin therefrom.

386. THE MUSCLES OF THE SOLE of the foot are often divided artificially into four layers. They naturally fall, however, into three groups—a central and two lateral. The first muscle exposed in the present dissection is the *flexor brevis* which immediately underlies the middle part of the plantar fascia.

Flexor brevis digitorum arises from the inner tubercle of the calcaneum, from the intermuscular septa, and from the fascia covering it. After a short course it divides into three fleshy slips, which become tendinous, the outermost detaching from its outer edge an additional or fourth tendon. These tendons

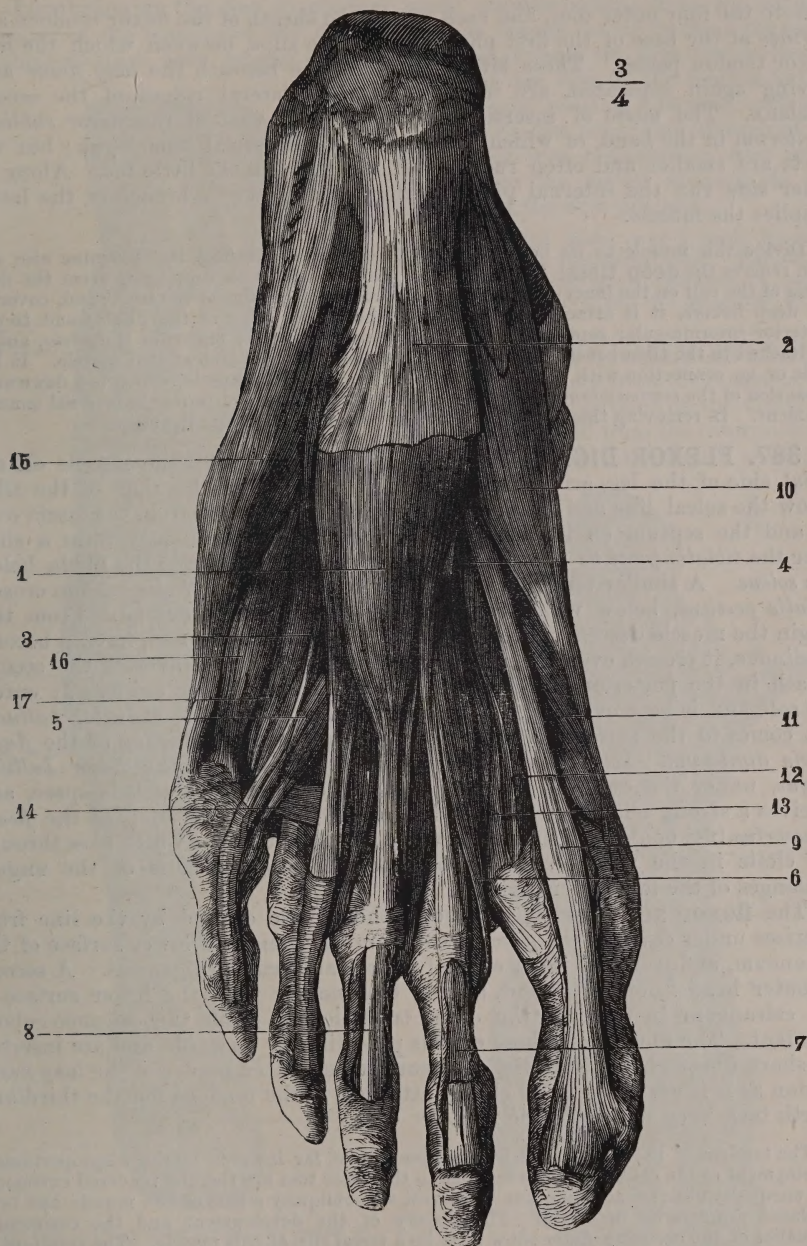


Fig. 607.—Superficial dissection of the sole of the foot, the plantar fascia being removed—1, flexor brevis digitorum; 2, portion of plantar fascia; 3, tendon of short flexor for little toe; 5, long flexor for little toe; 6, lumbricalis; 7, the sheath of the flexor longus tendon; 8, tendon in its sheath; 9, flexor hallucis; 10, abductor hallucis; 11, 12, flexor brevis hallucis; 13, adductor obliquus hallucis; 14, adductor transversus hallucis; 15, abductor minimi digiti.

pass to the four outer toes, and each enters the sheath of the flexor tendons and divides at the base of the first phalanx into two slips, between which the long flexor tendon passes. These lateral slips coalesce beneath the *long flexor* and, having again separated, are inserted into the lateral ridges of the second phalanx. The mode of insertion is the same as that of the *flexor sublimis digitorum* in the hand, of which this muscle is the serial homologue; but the parts are smaller and often rudimental, especially in the little toe. Along its inner side run the internal plantar artery and nerve; a branch of the latter supplies the muscle.

Divide this muscle as its belly is about to divide, and reflect it. Examine also and then remove the *deep tibial fascia* above. This is a partition dipping in from the deep fascia of the calf on the inner side, where it is attached to the edge of the tibia; and, covering the deep flexors, it is attached externally to the hinder edge of the fibula, and to the posterior intermuscular septum. Above, it becomes thin as it underlies the *soleus*, and it is attached to the tibia beneath its origin, and to the tendinous arch of that muscle. It has little or no connection with the fascia covering the *popliteus* muscle, which is a downward expansion of the *semimembranosus* tendon; below, it thickens and forms the internal annular ligament. In removing this fascia leave for the present the annular ligament.

387. FLEXOR DIGITORUM LONGUS (fig. 608, 7, 8), the muscle on the tibial side of the leg, arises from the hinder surface of the shaft of the tibia below the soleal line and internal to the oblique line, and from the fascia over it, and the septum on its outer side. This fascial origin may form a sling over the *tibialis posticus* above, and may even rise thereby to the fibula below the *soleus*. A similar tendinous arch sometimes exists where its tendon crosses *tibialis posticus*, below which sometimes the lower fibres extend. From this origin the muscle descends, overlapped by the *soleus* above, and, having become tendinous, it crosses over the *tibialis posticus* below, and traverses the second sheath in the posterior annular ligament behind the inner ankle. It enters the sole and is here overlapped a little by the origin of the *abductor hallucis*, but comes to the surface in the space laid bare by the reflection of the *flexor brevis digitorum*. It crosses superficial to the tendon of the *flexor hallucis longus*, under the outer cuneiform bone at the inner part of this space, and receives a strong slip from that tendon as well as the insertion of the *flexor accessorius* (fig. 609), after which it divides into four tendons which pass through the clefts in the *flexor brevis*, to be inserted into the basis of the ungual phalanges of the four outer digits.

The *flexor accessorius* (fig. 609; the muscle crossed by the line from 3) arises under cover of the *flexor brevis* from the inner and lower surface of the calcaneum, and from the inner edge of the calcaneo-cuboid ligament. A second or outer head is often present, arising tendinously from the lower surface of the calcaneum in front of the outer tubercle and from the calcaneo-cuboid ligament. The fibres from these origins pass directly forwards, and are inserted by short fibrous bands into the deep surface and outer border of the *long flexor* tendon as it is dividing, being chiefly attached to the tendons for the third and fourth toes, very seldom to the fifth.

The tendons of the *long flexors* having been thrust far inwards by the disproportionate development of the calcaneum, the tendons to the outer toes are thereby rendered extremely and unequally oblique, and in order to correct this obliquity a part of the muscle has been displaced downwards in origin. The history of the development and the commonest anomalies of the *accessory flexor* show it to be a tarsal slip of this muscle. The resultant is directed very nearly in the axis of the foot.

The connecting slip from the *flexor hallucis* is most commonly continued into the tendons for the second and third toes (54 per cent.), or into those of the second, third, and fourth (30 per cent.), more rarely into the second alone (15 per cent.), or to all (1 per cent.). A slip from the *flexor longus* may pass to the tendon of the *flexor hallucis* in about one in every four feet, illustrating the original unity of these muscles, which have become sundered by differentiation of function and crossed on account of the extreme pronation of the foot.

Lumbricales (fig. 607, 6) are four small muscles arising from the opposed surfaces of the tendons of the *flexor digitorum longus*, as far back as the point of their division, each arising from two tendons, except the first, which lies on the great toe side of the tendon for the second digit; passing forwards, each tendon lies on the tibial side of each of the four outer toes respectively, and is inserted into the dorsal aponeurosis and the base of the first phalanx.

Each tendon glides over a small bursa at the head of the metatarsal bone. The two innermost *lumbricales* are innervated by the internal plantar nerve, the two outermost by the external.

388. FLEXOR HALLUCIS LONGUS

(fig. 608, 11) arises from the posterior and postero-internal surface of the fibula below the *soleus* and from the intermuscular septa on each side; it descends enlarging,

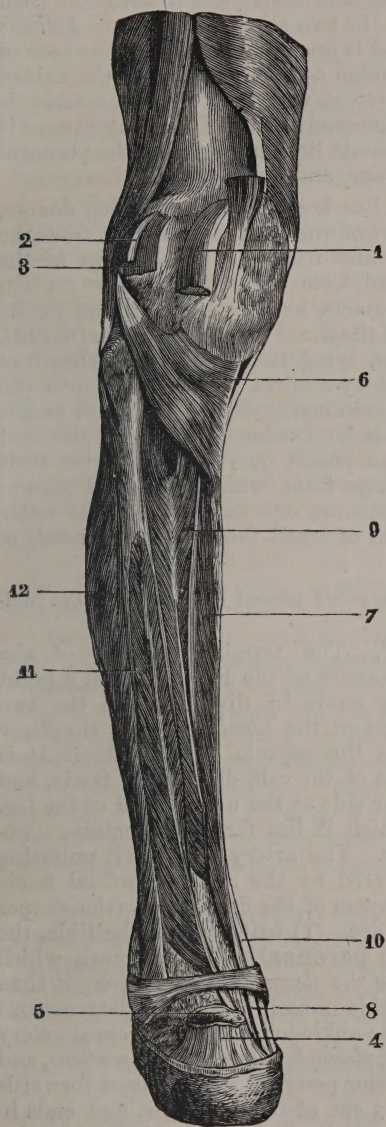


Fig. 608.—Deep muscles on the back of the leg—1, inner head of gastrocnemius; 2, outer head of gastrocnemius; 3, plantaris; 4, 5, tendo Achillis; 6, popliteus; 7, flexor digitorum longus; 8, its tendon; 9, tibialis posterior; 10, its tendon; 11, flexor hallucis longus; 12, peronei.

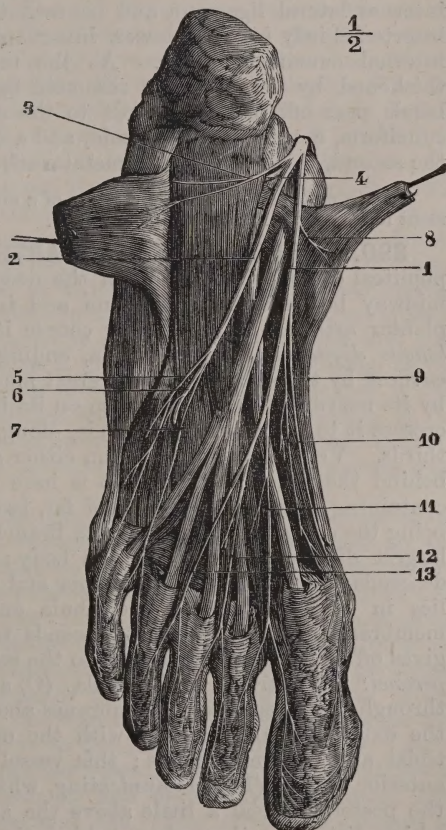


Fig. 609.—Muscles and nerves of second layer in the sole of the foot. For references see § 391.

and its fascicles are inserted in a penniform manner into its tendon, which, in its course, grooves the back of the inner ankle, the back of the astragalus, and the sustentaculum tali. It is crossed at the outer cuneiform bone by the *flexor digitorum*, and is connected to it as has been just described. Still farther forward the tendon passes between the two slips of the *flexor hallucis brevis*, between the two sesamoid bones, and is finally inserted into the base of the second phalanx of the hallux. Its tendon acts in the line of the axis of the foot. The sheath in the annular ligament traversed by this muscle is the deepest part of that ligament, and each successive part of its bony groove is converted by ligament into a canal. This muscle lies on the fibula, the peroneal muscles, *tibialis posticus*, interosseous membrane, and ankle.

389. TIBIALIS POSTICUS (fig 608, 9) lies between the two long flexors, arising chiefly from the upper and outer part of the back of the tibia, from the fibular half of the interosseous membrane, and from the tibialis area of the fibula, from the fascia which covers it, and from the intermuscular septum between it and the last. It is bipenniform above, but singly penniform for its lower half. Its tendon passes beneath that of the *flexor longus digitorum* (*ib.*, 10), and grooves the back of the inner malleolus, lying in the innermost sheath of the annular ligament; here it is surrounded by a bursa. It descends over the internal lateral ligament, and beneath the calcaneo-navicular ligament, and is inserted chiefly into the lower, inner and hinder border of the navicular and internal cuneiform bones. As the tendon passes over the navicular it is thickened by containing a sesamoid cartilage from which collateral fibrous bands pass off, one backwards to the calcaneum, one outwards to the outer cuneiform, a third to the cuboid, and a series of small fascicles to the heads of the second, third, and fourth metatarsals.

Tibialis posticus is the representative of a muscle rarely present except as a fibrous rudiment in the upper limb, the *radio-carpeus*.

390. POSTERIOR TIBIAL ARTERY.—The terminal branch of the popliteal (§ 369) descends upon the deep muscles of the leg, ending at a point midway between the calcaneum and inner ankle by dividing into the two plantar arteries. In this long course it lies on the *tibialis posticus*, the *flexor longus digitorum*, and the tibia, ending on the capsule of the ankle. It is covered by the skin, fascia, the great muscles of the calf, deep tibial fascia, and by its nerve, which, having been on its inner side at the upper third of the leg, crosses it to get to the outer side, along which it lies for the remaining two-thirds. Venæ comites lie one on either side. The artery can be felt pulsating behind the inner ankle, and it is here covered by the skin, superficial fascia containing a variable amount of fat, two layers of the deep fascia (the deeper being the annular ligament). Its branches are—(1) **nutrient** to the tibia, the largest diaphysial artery in the body; (2) **peroneal**, a large branch which descends beneath the *soleus* across and into the *flexor hallucis longus*; it then lies in a canal between the fibula and this muscle with the interosseous membrane in front; herein it descends to the ankle-joint. The peroneal artery gives off (A) muscular branches to the *soleus*, *flexor hallucis*, *tibialis posticus*, and *peronei*; (B) nutrient to the fibula; (C) anterior peroneal which passes forwards through the interosseous membranes about 3 cm. above the ankle, and ends in the external malleolar rete with the outer malleolar branch of the anterior tibial and external tarsals; this vessel may supplant the lower part of the anterior tibial; (D) communicating, which passes transversely inwards to join the posterior tibial a little above the ankle; (E) posterior peroneal branches which distribute themselves behind the outer ankle to the back of the outer malleolar rete; and (F) calcanean branches to the outside of the heel communicating with the external plantar. (3) **Muscular** branches from the posterior

tibial are larger but not so numerous as from the anterior tibial. They nourish the *soleus*, *tibialis posticus*, and *flexor digitorum*. (4) The **communicating** branch joins the peroneal as just described. (5) **Internal malleolar** passes to the rete over the inner ankle. (6) **Calcanean** supplies the inner side of the heel and the soft parts over it.

(7) The **internal plantar** artery passes forwards in the sole of the foot in the interval between the *abductor hallucis* (which at first covers it) and the *flexor brevis digitorum*, lying superficial to the border of the *long flexor* tendons. It passes forwards in the groove between the inner and middle parts of the plantar fascia as far as the ball of the great toe, sending branches into the *abductor hallucis* and the *flexor brevis digitorum*, and overlying the internal plantar nerve. At the base of the first metatarsal bone its main trunk dips deeply, and joins the digital branch from the *dorsalis pedis*, which is here passing to the cleft between the great and second toes. On its way it only gives off small branches, one of these accompanies and overlies the internal plantar nerve, and may join the superficial branch of the external plantar artery to form a **superficial plantar arch**. This, however, is seldom large enough to admit coarse injection.

(8) **External plantar**, the largest artery of the foot, passes forwards and outwards in the sole, at first between the calcaneum and the *abductor hallucis*, then under cover of the *flexor brevis* and on the *flexor accessorius* as far as the level of the fifth metatarsal. Turning then forwards between the *flexor brevis* and the *abductor minimi digiti*, it dips deeply inwards, and crosses beneath the *long flexor* tendons and *lumbricales*, lying on the *interossei* and forming the deep plantar arch on the level of the hinder fourth of the metatarsal bones. In its first stage, or that between the *flexor brevis* and *accessorius*, it gives off branches to the latter and to the heel. In its second, as it passes forwards between the *short flexor* and the *abductor minimi digiti*, it supplies the muscles of the little toe, and sends the branch to the outer side of the little toe. From the third stage, or that of the plantar arch, it gives (or receives) three perforating branches to join those of the metatarsal artery (p. 505); it gives off forwards four digital branches to the four interspaces, each of which joins the anterior perforating branch of the metatarsal, and then divides into two for the contiguous surfaces of the clefts. The plantar arch terminates by anastomosing with the first perforating branch of the *dorsalis pedis*; and it gives off an internal branch to the tibial side of the great toe. Each digital branch unites with its fellow by two terminal arches, one in the pulp of each toe, and one beneath the matrix of the nail. In many cases the arch is really the continuation of the perforating branch of the *dorsalis pedis*, the serial homologue of the radial artery and deep palmar arch.

391. THE POPLITEAL NERVE (p. 499), which at the lower border of the *popliteus* muscle changes its name and becomes **posterior tibial**, lies on the *popliteus*, and there gives off a large branch to that muscle, from which the nerves to the shaft of the tibia and to the interosseous membrane arise; the latter descends in that membrane to the ankle-joint, often expanding into a pseudo-ganglion at the lower fourth of the leg. Below these, the posterior tibial gives off branches to the *tibialis posticus*, the oblique nerve to the *soleus* and the periosteal nerve to the fibula, from which vasomotor filaments to the peroneal artery arise. About half way down the leg the branches to the *flexors digitorum* and *hallucis* arise, and a little lower the nerve to the posterior tibial artery. As it passes through its sheath under the annular ligament it sends off a cutaneous branch which pierces the annular ligament and divides into calcanean and plantar branches to the skin of the heel and sole. The nerve ends external to the artery, by dividing into internal and external plantar branches. The **internal plantar** (fig. 609, 7), the larger, becomes superficial on the outer side of the *abductor hallucis*, and passes forwards between this muscle and the *flexor*

digitorum brevis, where it divides into its terminal branches. Before its division it gives off branches to the *abductor hallucis* (*ib.*, 8) and to the *flexor brevis digitorum* (*ib.*, 3). Its first terminal branch passes forwards and inwards on the plantar side of the *abductor hallucis*, and supplies the inner head of the *flexor hallucis brevis* (*ib.*, 9) and the skin on the tibial side of the great toe (*ib.*, 10). The outer terminal branch passes between the plantar fascia and the tendons of the *flexor brevis digitorum*; it divides first into two, then its outer branch again bifurcates, and each of these three pass forwards to the three inner digital clefts (11, 12, 13), where each divides and supplies the opposed surfaces. From the first and second digital nerves arise the branches to the first and second *lumbricales* (11).

The **external plantar nerve** (*ib.*, 2) sinks between the *flexor brevis* and the *flexor accessorius* with the external plantar artery, and turns forwards between the *flexor brevis digitorum* and the *abductor minimi digiti*, in which interval it divides into superficial and deep terminal branches. Before dividing it gives off branches (1) to the *abductor minimi digiti*, and (2) to the *flexor accessorius*. The superficial terminal branch unites with the internal plantar and sends a branch to the cleft between the fourth and fifth toes (*ib.*, 7), which supplies the third and fourth *lumbricales* as well as the skin of the cleft; and one to the fibular side of the little toe, which sends the nerve of supply to the short muscles of the little toe and the *interossei* of the fourth interspace (*ib.*, 5). The deep branch of the external plantar supplies the remaining muscles of the sole of the foot (*ib.*, 6).

The usual distribution of the cutaneous nerves of the toes is given in the following table, but may vary, owing to varieties of the branching of the peroneal nerve:—

	PLANTAR.	DORSAL.
Great toe { Tibial side, . Fibular ,, . }	Internal plantar.	Musculo-cutaneous + Saphenous.
2nd toe { Tibial ,, . Fibular ,, . }	„	Anterior tibial + Musculo-cutaneous.
3rd toe { Tibial ,, . Fibular ,, . }	„	Internal branch of musculo-cutaneous.
4th toe { Tibial ,, . Fibular ,, . }	External plantar.	External branch of musculo-cutaneous.
5th toe { Tibial ,, . Fibular ,, . }	„	{ Sural nerve + External branch of musculo-cutaneous.

392. THE SHORT MUSCLES OF THE GREAT TOE are four—

1. **Abductor hallucis** (fig. 607, 10) arises from the inner tubercle of the calcaneum, from the internal annular ligament, the investing fascia, and the septum between it and the *flexor brevis*, by the latter origin arching over the plantar vessels and nerves and the inner tendons which pass beneath the annular ligament. Farther forward it has usually an origin from the tubercle of the navicular and, through the fascia covering it, from the base of the first metatarsal bone. The fibres converge to a tendon which is inserted into the inner side of the base of the first phalanx of the great toe and into the inner sesamoid bone.

It acts as a flexor and abductor, but its power of abduction is slight, and in an undisturbed foot it cannot move the great toe more than 8° inwards from the middle line of the first metatarsal. Divide its tendon and reflect it backwards, cleaning the underlying muscle.

2. **Flexor brevis hallucis** (fig. 610, 3, 4) arises by a narrow origin from the calcaneo-cuboid ligament and its prolongation underlying the cuboid and inner cuneiform bones, and from one of the slips of the *tibialis posticus* tendon; from this scarcely divided origin two bellies arise, which pass forwards, one to the

outer, the other to the inner sesamoid bone at the base of the great toe,

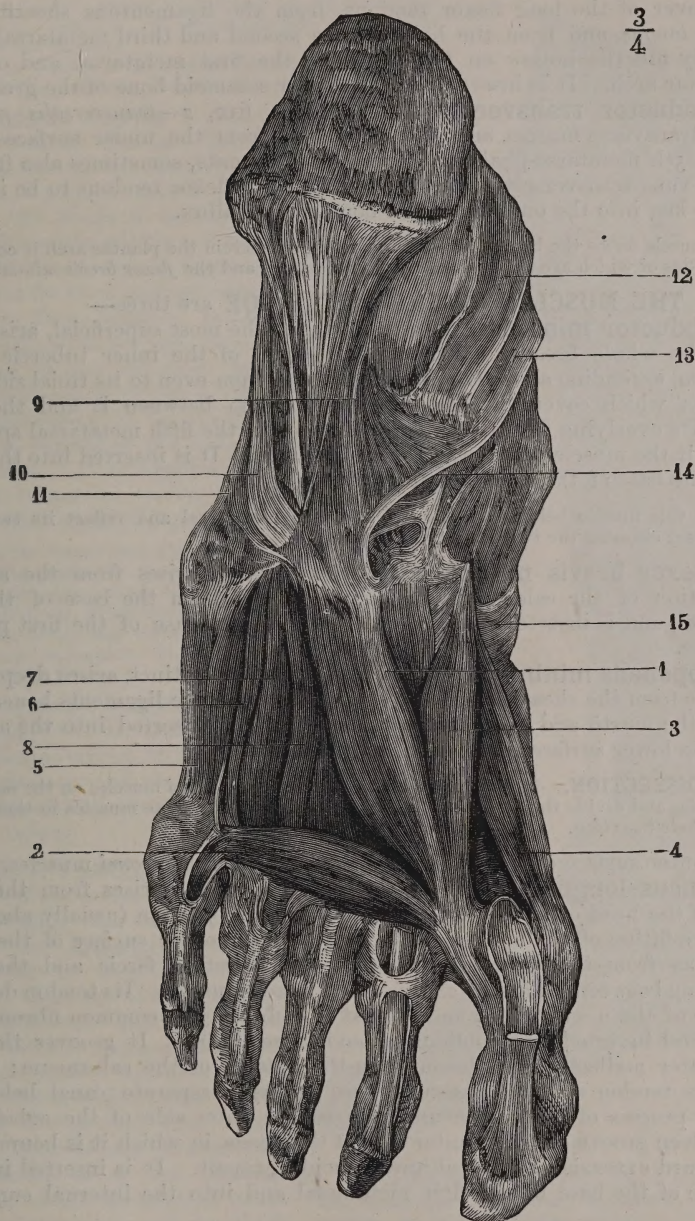


Fig. 6ro.—Deep muscles of the sole of the foot—9, calcaneo-cuboid ligament; 10, tendon of peroneus longus; 11, of peroneus brevis; 12, sheath of flexor hallucis; 13, 14, of flexor digitorum; 15, insertion of tibialis anticus.

the former uniting at its insertion with the *abductor*, the latter with the *adductor hallucis*.

3. **Adductor obliquus hallucis** (fig. 610, 1), external to the last, arises under cover of the long flexor tendons, from the ligamentous sheath of the *peroneus longus*, and from the bases of the second and third metatarsal bones. The belly fills the hollow on the outside of the first metatarsal and overlaps the plantar arch. It is inserted into the outer sesamoid bone of the great toe.

4. **Adductor transversus hallucis** (fig. 610, 2—*transversalis pedis*), a narrow transverse muscle, arises by three slips from the under surfaces of the 4th and 5th metatarso-phalangeal capsular ligaments, sometimes also from the 3rd, and runs transversely under cover of the long flexor tendons to be inserted with the last into the outer sesamoid bone of the hallux.

This muscle forms the base of the plantar triangle wherein the plantar arch is contained, the two sides of which are the *adductor obliquus hallucis* and the *flexor brevis minimi digiti*.

393. THE MUSCLES OF THE LITTLE TOE are three—

1. **Abductor minimi digiti** (fig. 607, 16), the most superficial, arises from nearly the whole breadth of the under border of the inner tubercle of the calcaneum, extending above the *flexor brevis digitorum* even to its tibial side, from the fascia which covers it, and from the septum between it and the *flexor brevis*. Its overlying fascia is strongly attached to the fifth metatarsal spur, and through it the muscle takes origin from that part. It is inserted into the outer side of the base of the first phalanx of the little toe.

Divide this muscle behind the base of the fifth metatarsal and reflect its two parts, exposing and cleaning the two underlying muscles.

2. **Flexor brevis minimi digiti** (fig. 610, 5) arises from the anterior prolongation of the calcaneo-cuboid ligament and from the base of the fifth metatarsal, and is inserted into the outer side of the base of the first phalanx of this toe.

3. **Opponens minimi digiti** (*ib.*, 6), not always distinct, arises deeper than the flexor from the sheaths of the *peroneus longus* and the ligaments beneath the heads of the fourth and fifth metatarsal bones. It is inserted into the anterior half of the lower surface of the fifth metatarsal bone.

394. DISSECTION.—Remove the fascia covering the *peronei* muscles on the outer side of the fibula, and divide the sheaths which bind the tendons of these muscles in their places as far as their insertion.

The outer surface of the fibula is covered by the two *peronei* muscles.

Peroneus longus (fig. 611, 8), the more superficial, arises from the outer surface of the head of the fibula and from a variable portion (usually about the upper two-fifths) of the upper and back part of the outer surface of the shaft, as well as from the contiguous area of the investing fascia and the septa intervening between it and the extensor and flexor muscles. Its tendon descends over that of the next muscle, and at first is included in a common fibrous canal with it, and invested by a common synovial membrane. It grooves the back of the outer malleolus, and descends on the outside of the calcaneum; here it leaves the tendon of the *peroneus brevis*, enters a separate canal below the trochlear process of the calcaneum, grooves the outer side of the cuboid, and enters a deep groove on the plantar side of that bone, in which it is bound down by a forward extension of the calcaneo-cuboid ligament. It is inserted into the outer side of the base of the first metatarsal and into the internal cuneiform bone.

The plantar portion is invested with a separate synovial bursa. The tendon is thickened at the malleolus, and still more so at its second alteration in direction at the trochlear process of the calcaneum; here it has often a sesamoid cartilage and occasionally a sesamoid bone. The upper fibres are often attached to the external lateral ligament of the knee, which was originally the femoral origin of this muscle, but which has degenerated into a ligament, and has become separately attached to the femur and fibula. At the neck of the fibula, 3 cm.

below the styloid process, the muscle is pierced by the peroneal nerve, whose musculo-cutaneous branch passes downwards in its substance for a short distance. It represents the *flexor carpi ulnaris* of the forearm.

From its sheath in the sole of the foot the *adductor obliquus hallucis* and the *flexor brevis minimi digiti* arise.

Peroneus brevis is shorter and deeper, arising beneath the last from the rest of the outer surface of the shaft of the fibula, as far down as its lower fourth. There is seldom a line on the fibula to indicate the division between the origin of this and the last muscle, and very little fascial sheath between the muscles. It arises also for the intermuscular septum, between it and the *flexor hallucis*. It descends behind the outer ankle with the last, from which its tendon separates at the trochlear process of the calcaneum, where it enters a separate groove, and passes forwards, to be inserted into the outer and back surface of the base of the fifth metatarsal bone. It is supplied by a branch of the musculo-cutaneous nerve, and by branches of the anterior tibial and peroneal arteries.

From its insertion a slip of tendon passes forwards, pierces the tendon of the *peroneus tertius*, and ends in the extensor aponeurosis of the little toe. This slip is called *peroneus quinti digiti*; it is rarely absent, and still more rarely has an independent belly, the normal condition in marsupials. It represents the *extensor carpi ulnaris* of the forearm.

The *peronei* extend the foot, raise its outer edge, and evert it, thus tending to supinate it. Extravagant action of these muscles co-existing with relaxation of the calcaneo-navicular ligaments produces the form of flat-foot, called *talipes valgus*.

395. INTEROSSEI.—By removing the adductors of the pollex and the long flexor tendons, and dividing the transverse interdigital ligaments, the **interossei** are exposed. These are seven in number—three plantars, one-headed muscles, which adduct the toes towards the middle line of the second toe, and four dorsals, two-headed muscles, which abduct the toes from the middle line of the second toe. Each *dorsal interosseous*, except the first, arises from the opposed surfaces of the metatarsal bones in each interspace, and its heads are separated by the perforating artery. These muscles are visible on the dorsum of the foot.

The **first dorsal interosseous** arises by an inner head from the base of the first metatarsal and

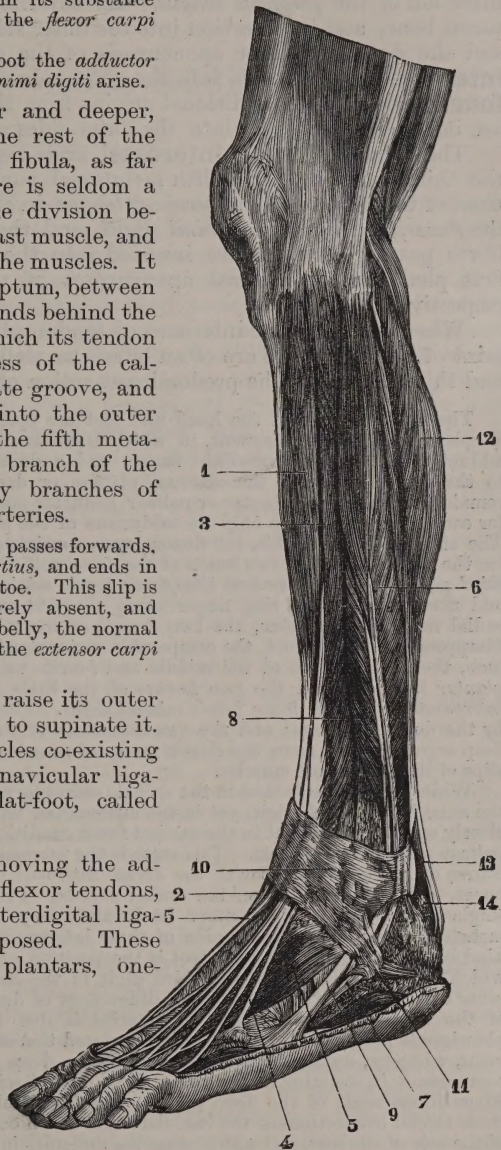


Fig. 611.—Muscles on the outer side of the leg—1, 2, tibialis anticus; 3, extensor digitorum; 4, peroneus tertius; 5, flexor hallucis proprius; 6, peroneus longus; 7, its tendon; 8, peroneus brevis; 9, its tendon; 10, anterior annular ligament; 11, external annular ligament; 12, gastrocnemius; 13, tendo Achillis; 14, calcaneum.

from the outer side of the internal cuneiform bone, sometimes from the insertion of the *peroneus longus*. Its external head is from the second metatarsal bone, and its insertion into the inner side of the base of the first phalanx and the dorsal extensor aponeurosis of the second toe. The **second dorsal interosseous** is inserted into the outer side of the second toe; the **third and fourth** which takes additional origins from the sheath of the *peroneus longus*, are inserted respectively into the outer sides of the third and fourth toes.

The **three plantar interossei** arise respectively from the tibial sides of the third and fourth and fifth metatarsal bones, from the sheaths of fascia in front of the tendon of the *peroneus longus* in close connection with the origin of the *flexor*, and *opponens minimi digiti*, and the two outer *dorsal interossei*. The fibres passing forwards are inserted into the tibial sides of the bases of the first phalanges and dorsal aponeuroses of the third, fourth, and fifth toes respectively.

Where each plantar interosseous tendon plays over the metatarso-phalangeal joint of the toes there are often bursæ, as well as for the tendons of the second and third dorsals. The predominant action of the pedal *interossei* is flexion.

The short muscles of the hand and foot are specialisations in different directions of a simpler embryonic arrangement, in which there are for each digit four muscles—a ventral adductor, a paired intermediate flexor, and a dorsal abductor. The muscles superficial to the deep division of the external plantar, or deep branch of the ulnar nerve, are the remains of a series of plantar or palmar adductor muscles, whereof originally there was one for each finger. In man only the adductors of the pollex and hallux survive of this series. The stratum beneath this, the flexor layer, consists of paired slips for each digit, the two for the pollex being the two heads of the *flexor pollicis*, the two for the little finger being the *third palmar interosseous* and the *flexor brevis minimi digiti*, the ulnar flexor of the index and the radial of the ring finger being the *first and second palmar interossei*, while the radial flexor of the index, the two flexors of the middle, and the ulnar of the ring have disappeared. In the foot, the comparable series consists of the two heads of the *flexor hallucis*, the radial flexors of the middle and fourth toes, represented by the *first and second plantar interossei*, and the two flexors of the little toe, represented by the *third plantar interosseous* and the *flexor brevis minimi digiti*. The dorsal abductor series is represented by the dorsal *interossei* and the two abductors of the extreme digits. The *opponentes* are deep segmentations from the flexor group of muscles. The *lumbricales* are only displaced slips of the long flexor muscles.

While it is probable that in the archaic chiropterygium the muscles were disposed around the axial bone in each digit, yet in the mammalian hand and foot the bones have become so closely approximated that in the earliest foetal condition of the hand all the muscles are on the palmar and plantar aspects. This state is the permanent one in many mammals, but in the course of human foetal growth the *dorsal interossei* become pressed backwards between the bones, until they appear on the dorsal surface. Primarily the *dorsal interossei* have only single heads, but as they move backwards they become secondarily connected to the metatarsal bone on the other side of their interspaces. The chief structural difference of kind between the hand and the foot is the position of the axis of adduction and abduction, which is the middle line of the third digit in the hand, but the second in the foot. The other differences are mainly extreme differences of degree and adaptation. The suppression of the superficial plantar arch of arteries is due to the compression of the surface in plantigrade progression, and there is correlated therewith an interesting hydraulic arrangement, whereby, owing to the disposition of the deep septa of the plantar fascia, superficial compression in standing makes tense those deep fascial processes which are attached to the adventitious coats of the deep plantar vessels, thereby actually holding them open. It is these fascial connections of the vascular coats which occasion the profuse bleedings in wounds of the sole of the foot, and which cause the difficulty in isolating the vessels to ligature them.

HEAD AND NECK.

396. SURFACE MARKINGS.—While the body is in the position for the dissection of the perineum, the surface markings of the head and neck should be observed, the scalp dissected, and the brain removed.

The margin of the hairclad area of the scalp appears abrupt in front of the mastoid processes, but is less perfectly defined posteriorly. The skin of this region is pale, even white, during life, and is so closely tied to the subjacent textures, that in contused wounds, the whole thickness of the scalp usually gives way. The scalp hairs are more or less elliptical in section, and in different individuals they vary in setting, colour, length, and diameter; fair hair being usually more slender and more closely set than dark. The hair follicles dip through the skin and are directed obliquely, for the most part diverging from the obelion in a somewhat spiral series. The axis of each follicle may be straight or curved, the hair accordingly being straight, wavy, curly, or woolly.

Fair hair is usually from .049 mm. to .070 in diameter; red hair from .057 to .078; reddish chestnut brown from .047 to .075; dark brown from .054 to .097; and black from .067 to .101. The closeness of planting is usually in the inverse ratio of the diameter, and is generally in the proportion of 100 fair to 90 brown or 82 black hairs. The average number of scalp hairs in the male may be estimated at about 125,000, a little more than twice as many as are found on the rest of the body. At the vertex the hairs are usually about 162 to the sq. cm., on the front of the scalp about 120, and at the back about 138. The hair of the negro is, in section, a long ellipse with an index $\left(\frac{\text{axis minor} \times 100}{\text{long axis}} \right)$ of 50 or thereabouts, while the index of the average European hair is about 68; that of Malays and Turanians 80. The coarsest hair is that of the Malays, Micronesians, and East Asiatic Turanians.

The cuticle of the scalp is moderately thick, with a brittle, easily-detached stratum corneum, whose shed particles when agglutinated by dried sebaceous secretion constitute *dandriff*. The liability of the scalp to cutaneous disease is largely due to the mechanical retention, by the hair, of irritant particles of dirt, or parasites. The sweat glands of the scalp are small, occasionally opening into the hair follicles, but the sebaceous glands are large, and about 135 to the sq. cm.

The surface of the skin of the forehead is more or less uneven in adult males, becoming wrinkled by habitual muscular action. It is smoother in females and in children, and is bounded below by the hair-crowned **superciliary arches** or eyebrows, between which at the **fronto-nasal sulcus** there is generally a nearly naked interval or **glabella**, only bearing small slender hairs, except in synophryous faces. The hairs are directed upwards and forwards at the inner fourth of the **eyebrow**, but upwards and outwards at an increasing angle for the rest of the arch; they are usually about 118 to the sq. cm. The upper hairs are frequently decurrent, the lower ascending. The skin of the upper eyelid below the brow is thin and bears very slender short hairs with small sebaceous glands and many sweat glands, especially near its margin, and is marked, above its free border, by one or two folds of retraction (the superior palpebral fold) conspicuous when the eye is open, but flattened out in the closed eye. This fold deepens internally to form the **oculo-nasal recess**. Near the lower border of the upper lid is a *superior marginal sulcus* parallel to the free border. The two lids bound the transversely elongated **riectus oculi** wherein the eyeball appears, and their angles of union externally and internally are called respectively the **outer** and the **inner canthus**. The former is a

sharp angle, at which the upper lid slightly overlaps the lower. The latter is rounded, depressed, on a lower level than the outer, the fissure between the lids extending 5 mm. internal to the eyeball; and its margins bound a bay-like space, the **lacus lacrymalis**, in which lies a small reddish body, the **caruncula lacrymalis**, between which and the eyeball is a small fold of mucous membrane, the **plica semilunaris** or rudiment of the third eyelid, whose concave free margin is directed upwards and outwards. The border of each lid is thickened, flat-edged where it comes in contact with its fellow, sharp-edged towards the eyeball (*limbus posterior*), and it bears close to its more rounded anterior edge (*limbus anterior*) several rows of up-curved hairs, the **cilia**, each 7 to 15 mm. long; longest in the middle, diminishing in length toward either canthus. The hairs of the lower row of cilia or eyelashes are shorter and weaker than the upper, and have a down-turned concavity. Behind these there opens a row of sebaceous glands, the **Meibomian follicles**. The hairs extend almost to the external canthus, but generally stop short near the inner at a small conical **lacrymal papilla** on each lid (5 mm. from the canthus on the upper, 6 on the lower lid); on the inner side of the summit of which there is a minute hole, the *punctum lacrymale*, which is closely applied to the surface of the eye. The lower papilla is larger and on a plane external to the upper. A pin passed sagittally backwards through the outer canthus will pierce the outer circumference of the eyeball, but one passed midway between the upper and lower lacrymal papilla will be almost tangential to the eye, so the whole lacus lies internal to the globe.

The **conjunctiva** is a soft mucous membrane, beginning, continuous with the skin, at the free border of each lid and lining its deep surface. At the root of each lid this membrane is reflected on the eyeball and is continued over its front surface. These two portions of conjunctiva are named respectively **palpebral** and **ocular**, and the fold of reflection under each lid where these portions are continuous between the eyelid and eyeball, seen by drawing the lid forwards from the eyeball and looking under it, is the *fornix conjunctivæ*. The superior fornix is much deeper than the inferior, and hence it is much more difficult to remove particles of foreign matter therefrom, than when they lie between the lower lid and the eyeball. The lower lid is smaller than the upper, and is in some eyes marked by an inframarginal fold. It is usually marked off from the infraorbital region by an **infrapalpebral sulcus**, but this is inconstant as the motion of the lower lid in opening the eye is slight.

Occasionally in Westerns, normally in Mongolians, a fold of skin descends internally from the upper lid to the lower, overlapping the inner canthus (**epicanthus**). This purely cutaneous fold, which includes no muscle nor fibrous structure, is an archaic feature and is usually present in the foetus, but even when present until birth it may disappear as growth progresses. Below the infrapalpebral sulcus is a variable **palpebro-malar sulcus** which deepens and often becomes a characteristic marking in old age, or in wasting diseases, which gives to the eye the appearance described as "hollow." While examining the face the student should practise the passing of a fine wire probe into the lacrymal puncta, and should also practise eversion of the upper lid.

Outside the palpebro-malar sulcus is the **malar** region, wherein the cheek is generally red (hence the name), the cutaneous network of vessels being sometimes conspicuously large in the adult. The skin is here clothed with fine hairs, but in the male these become coarser towards the ramus of the jaw forming the whisker. Sebaceous glands are here very large, especially in the male adult.

The **nose** presents a ridge (dorsum) and two sides expanding below into the *ala* which bound the **nares** or nostrils externally. The skin is thin on the dorsum, but thickens on the ala, where it contains large complex sebaceous glands. Internally the nostrils are separated by the thick bar, **columna nasi**,

continued backwards from the *apex nasi* or tip of the nose, whose sides are clothed with fine hairs (vibrissæ). Above each ala of the nose is the **alar sulcus**, often continued downwards and outwards towards the mouth as the **naso-labial sulcus**.

The transverse **mouth**, about 5 cm. long is bounded above and below by the lips. The upper lip is marked by a vertical median groove, the **philtrum**. Each lip is margined by a red edge, more clearly marked off from the skin of the upper than from that of the lower, and characterised by the absence of hair follicles and mucous glands and by the transparency of its cuticle. The free border of the upper lip projects downwards as a median lobe at the philtrum, and a process of ordinary skin invades the red margin at this point. The junction of the two lips at the angle of the mouth is called the commissure of the lips, and here the red border is narrowest. A transverse sulcus (**s. mento-labialis**) separates the lower lip from the chin.

The facial skin is thin, with large sebaceous glands, and its cutis often presents superficial brownish pigmented patches (freckles), especially in persons with red or red-brown hair. The area of the upper lid and that above the palpebro-malar sulcus is frequently the seat of periodic *uterine chloasma*, darkening perceptibly during the menstrual period. This area is smooth when the reticular layer contains much fat, but liable to be wrinkled at right angles to the lines of muscular action when the subcutaneous fat is absorbed. A few modified sebaceous glands, without hair follicles, extend into the red margin of the upper lip, especially towards its angles; but there are none on the lower, and on both the small papillæ of the cutis are quite buried in the stratified epithelium (fig. 639).

The peculiarities in structure of the upper lip are traces of its compound origin (p. 16), as are the appearances seen in the inner canthus. The external auditory meatus, is a remnant of the visceral cleft between the mandibular and hyoid arches.

The corrugated projection of the **pinna** or **external ear** (fig. 613) usually equals the nose in length, and is placed on the side of the head. A line joining the topmost point of one ear to that of the opposite side being usually 1.5 cm. above the root of the nose. Seen from its front and outer side it consists of an inrolled peripheral margin above, the **helix**, bounding a concavity, the **fossa of the helix**. Within this is a rounded, variable projection, the **antihelix**, approximately parallel to the helix, which bifurcates above and in front; the two branches being separated by a shallow pit, the **fossa of the antihelix**. The antihelix bounds a deep concavity, the **concha**, into which the anterior end of the helix turns and is continued backwards, here lying below the antihelix, and separated from its lower branch by the deepest part of the fossa of the helix.

In front of the concha there is a flattish, somewhat conical eminence, the **tragus**, bearing usually in the male on its hinder surface a tuft of hairs. This is separated below by a notch (*fossa angularis*) from a smaller prominence placed at the lower and hinder end of the antihelix and called the **antitragus**. Below this there projects downwards the soft, fatty, and areolar process, the **lobe**. Seen on its posterior side the helix has a convex margin, and is separated from the convex hinder surface of the concha by a **periconchal sulcus**, which is the reverse side of the antihelix.

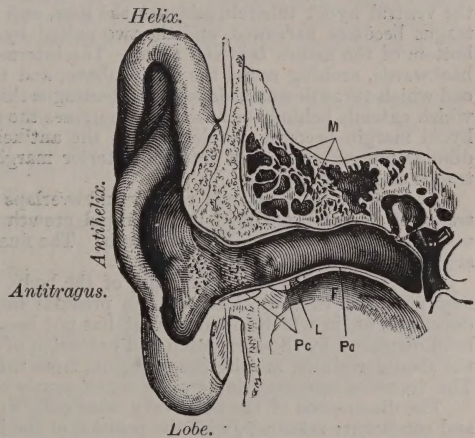


Fig. 612.—Coronal section through ear passage.

The margin of the helix is often irregular and toothed above, one prominence (Woolner's tip) being that which Darwin surmised to be the representative of the helical apex of other mammals.

The ear is covered by a thin and not very sensitive skin, supplied in front by branches of the auricularis magnus and auriculo-temporal, behind by the auricularis magnus nerve. This layer is closely adherent to the cartilage and covered by soft hair, sebaceous and sudoriferous glands are also distributed on its surface.

Beneath the skin is a plate of wrinkled yellow fibro-cartilage to whose folds the irregularities of the surface of the pinna are due. This layer presents certain processes which are united or rounded off by soft parts, and so do not appear through the skin. One of these is the **agger helieis** posteriorly and above at the back of the concha. Another is the **cauda helieis anterior** which projects in front towards the root of the zygoma. A notch ascends between the hinder margin of the antihelix and the antitragus, behind which is a **cauda helieis posterior**.

The cartilage of the ear is attached by the tubular inward extension of the concha to the edge of the external auditory meatus of the tympanic bone. In this expansion are several clefts, the fissures of Santorini.

The pinna is fixed by two ligaments, an anterior from the root of the zygoma to the front of the helix, and a posterior from the mastoid process to the back of the auricle.

On the dorsal or convex surface of the auricle there are two sets of muscular fibres, *transverse auricular* crossing from the concha to the hinder edge of the helix, and *oblique auricular* ascending from the top of the concha to the top of the back of the antihelix. On the front or outer side of the concha are four sets of muscular fibres—(1) *tragic*, nearly vertical, lying on the front of the tragus, often divided into a longer and shorter series of fibres (fig. 657); (2) *antitragic*, crossing the antitragus obliquely to be inserted into the cauda helieis posterior; (3) *helieis major*, ascends from the cauda helieis anterior along the front of the helix to its highest point; (4) *helieis minor*, passing from the floor of the concha to the anterior end of the helix. All these muscles are supplied by the facial nerve.

The outer ear is the dilated margin of the first and only branchial cleft. In the fifth week two tubercles arise on the mandibular side of the cleft, and three on the hyoid margin of the cleft, while a sixth or intermediate tubercle is placed at the neural end of the cleft. The ventral mandibular tubercle (*tuberculum tragicum*) becomes eventually modified into the tragus, the intermediate of the tubercles on the hyoid side becomes the antitragus, while the ventral hyoid tubercle becomes the lobe, and the interval between the tragus and antitragus becomes narrowed, and the two united by an intertragic ridge which rises from the bottom of the fissure between them. The intermediate tubercle extends both forwards and backwards, arching round the others above, and ultimately forming the helix. Its anterior end which turns downwards towards the tragus thickens into a *spina helieis*, while its posterior which extends behind the antitragus becomes the cauda helieis. The neural tubercle on the hyoid margin becomes developed into the antihelix, and the neural tubercle on the mandibular margin shades off into the anterior margin of the concha at the notch between the tragus and the helix.

At first the helix extends rapidly and overlaps the antihelix, but this condition which is transient becomes modified by the rapid growth of the antihelix, which widens the pinna until its width nearly equals its length. The final adult proportions of length and breadth are not attained until about puberty.

The **neck** is the narrowest part of the body, corresponding to the interval between the first post-oral visceral cleft and the preaxial limit of the coelom. It is a region late in development, in which the mesoblast has not been recognisably cleft, and whose parts have been displaced by the elongation and extension of the axial skeleton, by the development of the shoulder-girdle, and by the recession, from the head, of the heart and thoracic viscera. The traces of metamerism here are consequently confused and unequal.

The dimensions of the neck vary *absolutely* with the general size of the body, age, sex, and condition; *relatively*, with the position of the head. When divided horizontally opposite the fifth cervical vertebra (fig. 621), the vertebral column and its muscles can be seen to make 0·7 of the whole sectional area; the important vessels, nerves, and viscera making up only 0·3. This shallowness of the area occupied by the important parts must be constantly borne in mind by the surgeon.

Divisions.—The surface of the neck is divisible into three areas—a median posterior, the **nuchal triangle**, and two symmetrical anterior **quadrilateral spaces** meeting in the anterior median line.

The former (fig. 623) is co-extensive with the area covered by the *trapezius*, whose dissection has been described in connection with the back (p. 250), of which it is an integral part, and its contents are, to some extent, the common property of the dissectors of contiguous territories. The *trapezius* and *levator anguli scapulae* should be conjointly examined by the students in

charge of the upper extremity and neck; the underlying *splenius*, *complexus*, the cervical continuations of the *erectores spine*, and the *semispinales* by the students dissecting the neck and the thorax. The deeper cervical muscles belong to the dissector of the neck. This portion of the dissection (described at p. 258) should be carried out while the body lies on its face.

The cervical quadrilateral space is bounded below by the clavicle, internally by the median line, externally by the edge of the *trapezius*, and above by the base of the lower jaw and a line drawn from its angle to the superior occipital ridge. From each side of the presternal notch, the edge of the *sterno-mastoid* muscle can be felt ascending obliquely backwards to the mastoid process, subdividing the quadrilateral into **anterior** and **posterior triangles**. The base of the hinder of these spaces is usually depressed into a **supraclavicular fossa** above the clavicle, in which the subclavian arteries lie.

In the middle line of the neck, the hyoid bone can be felt lying transversely behind the chin. The upper border of the great cornu of this bone at each side is the surgeon's guide to the lingual artery. Below the hyoid, the thyroid cartilage projects in the middle line, forming the pomum Adami of the older writers, so called as it is much larger in the adult male than in the female. The sulcus between the hyoid and thyroid is the **thyro-hyoid space**; that below the thyroid is the **crico-thyroid space**, in which the operation of laryngotomy is performed. Below this depression, the edge of the ring-like cricoid cartilage projects, and a little lower the soft isthmus of the thyroid body can often be felt as it lies on the second and third rings of the trachea, and marks the upper limit of the region in which tracheotomy is to be performed. The trachea, itself, which lies deeply in the presternal notch, is too deep and too closely covered by fascia to be easily felt, except in a very thin neck.

The obliquity of the line of the clavicle should be noted. A horizontal line, drawn from the acromial end of one clavicle to that of its fellow, will cut the fourth cervical vertebra, and will divide the larynx through the cricoid cartilage in the male adult, but is lower in the child.

The course of the carotid is indicated by a line drawn from the sternal end of the clavicle to the external auditory passage, and the artery can be felt pulsating during life along the edge of the *sterno-mastoid*. Its facial branch can be felt to beat where it crosses the lower jaw in front of the *masseter* muscle. The branch from the temporo-maxillary to the external jugular vein is often recognisable through the skin, as it descends vertically across the *sterno-mastoid* in a line from the angle of the jaw to the middle of the clavicle.

Before dissection, the student should mark, with an aniline pencil, on the shaven head the lines of the cerebral convolutions (as given in § 538).

Dissection.—The head having been elevated on a block, divide the skin (1) from the root of the nose to the occipital protuberance, and (2) across the vertex from one mastoid process to the other. The dissection of the four flaps of skin, thus marked from the subjacent textures, is a task requiring much care, as the skin is closely connected to the underlying fascia into which the oblique follicles sink. The plane of separation is marked by a layer of small granules of fat embedded in the reticular fibrous tissue, which ties the skin to the epicranial aponeurosis beneath it. Beyond the hair-clad region, the subcutaneous layer is a little more distinct, but it is hardly possible to separate a definite superficial fascia from the deep layer of the cutis in any part of the hairy scalp. The external ear should be left uninjured. The corium is richly furnished with lymphatic vessels around the hair follicles (fig. 613).



Fig. 613.—Lymphatic plexus in the corium of the scalp around the hair follicles (2).

397. EPICRANIAL APONEUROSIS.—The dense layer exposed by the

From the anterior edge of this aponeurosis, on each side the thin, pale, flat **frontalis** muscle (larger than the occipitalis) descends in the forehead to be inserted into the skin and deeper structures of the eyebrow, and by an indistinct slip (needlessly dignified with a separate name, *pyramidalis nasi*) into that of the root of the nose. These muscles raise the brows and wrinkle the forehead transversely, or acting from fixed brows they can draw the scalp forwards. The contiguous borders of the two *frontales* coalesce for their lower half, and are separated by loose connective tissue above. Some of the innermost fascicles are divided by a tendinous intersection. Between the *occipitales* there is a median area in which the epicranial aponeurosis is attached to the *linea nuchæ suprema*.

In the dissection of the scalp, the following vessels and nerves are met with in order from the median line of the forehead to the median line of the occiput:—The middle frontal vein, the supratrochlear nerve and frontal artery, the supraorbital artery and nerves, the temporal branch of the orbital nerve, the temporal branch of the facial, the anterior temporal artery and vein, the auriculo-temporal nerve, the posterior branch of the temporal artery, the great auricular nerve, the posterior auris artery, the lesser occipital nerve, the occipital artery and vein, the great occipital nerve, and occipital branch of the third cervical nerve. These should now be sought for, cleaned and preserved for detailed examination at a later stage.

398. MUSCLES OF THE EAR.—Three very thin superficial muscles converge to the external ear.

Retrahens aurem (fig. 614).—The strongest of the series, consists of two fascicles which arise from the temporal bone above the mastoid process, and pass horizontally forwards above the insertion of the sterno-mastoid to be inserted into the *agger heliæ*, a vertical thickening on the back of the auricle.

A small rudimental muscle, the **transversus nuchæ**, occasionally absent, and often represented by a fibrous band, arises from the occipital protuberance and passes along the superior nuchal line above the *trapezius* to end either in the fascia, or in the tendon of the *sterno-mastoid*, or in the *retrahens aurem*.

Attollens aurem, very thin and fan-shaped (fig. 614), arises from the surface of the temporal aponeurosis below the attached lateral edge of the epicranial aponeurosis, and is inserted into the upper and anterior part of the auricle, or, more commonly, into the skin at its base.

Attrahens aurem, still thinner, usually rudimental, arises from the skin over the temporal aponeurosis close to the outer border of the *frontalis*; it crosses the temporal artery and is inserted in the subcutaneous tissue in front of the auricle.

These two are lateral segmentations of the same muscular sheet as the *frontalis*, and supplied like it by the temporal branch of the facial nerve. The *retrahens* and *transversus* are segmentations of the same layer as the *occipitalis*, and are supplied by the posterior auricular branch of the facial nerve (p. 576).

The *frontal* and *occipital* muscles act as a digastric occipito-frontal muscle; the epicranial aponeurosis being the central tendon. Owing to the vascularity of the compact scalp formed by the united skin and epicranial aponeurosis, it rapidly recovers from injury, hence in contused and lacerated wounds, be the loosened fragments of scalp ever so ragged and dirty, they should be cleansed and replaced and not trimmed away. The obsolete operation of bleeding by arteriotomy was performed on the anterior branch of the temporal artery.

399. REMOVAL OF THE BRAIN—Dissection.—Divide the scalp to the bone in the intermastoid line, and reflect the two concave flaps thus separated, forwards and backwards as far as the brow-ridge and nuchal line respectively. Observe on each side the attachment of the temporal aponeurosis (p. 577) to the outer temporal crest, and cut it through along a line carried horizontally round the skull 2 cm. above the brow-ridge, and the same distance above the occipital protuberance. The pericranium, or periosteum, of the cranial bones is easily detached, except along the sutures or in the skulls of the aged.

Having bared the skull, divide with the saw the outer table and diploë of the frontal, parietal, and occipital bones along this line, then cut through the inner table with a mallet and chisel, and prize the skull-cap from the underlying dura mater, which should on no account be cut, even when closely adherent, except as a last resort.

The outer surface of the dura mater (p. 61) thus exposed, appears rough and bespotted

with torn vessels, especially along the middle line where its connection with the bone was closest. The tree-like branchings of the middle meningeal artery (p. 582) are conspicuous on each side, and near the obelion many *corpora Pacchioni* (p. 60) usually appear as warty granular bodies, projecting in clusters through deficiencies in the dura mater and often indenting the bone.

Divide the dura mater on each side at the level at which the bone has been sawn, leaving about 2 cm. in the middle line in front and 6 cm. behind uncut. By raising the membrane from the surface of the brain on one side, the subdural space is opened and the deep surface of the membrane appears smooth and glistening, moistened by a little serous fluid. Along the middle line the *superior longitudinal venous sinus* (fig. 616) can be traced (p. 532) backwards, making a groove on the roof bones of the skull. Its interior can now be

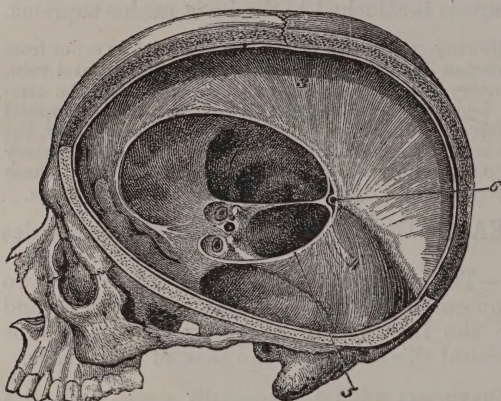


Fig. 615.—View of the dura mater lining the interior of the skull, the brain having been removed—1, cut edge of dura mater; 2, parietal dura mater; 3, falx cerebri; 4, tentorium cerebelli; 5, concave edge of tentorium, forming boundary for the superior occipital foramen; 6, opening of vena Galeni in the straight sinus.

examined by slitting it open along its convexity from before backwards. Beneath the dura mater four or five veins are seen on each side lying in the sulci on the surface of the cerebrum, and passing inwards to discharge into the sinus, each turning abruptly forward as it is about to open thereinto, an index of the lateness of the frontal preponderance in brain growth.

By dividing these veins on one side as they enter the sinus, and drawing the cerebral hemisphere of that side gently outwards, a sickle-shaped process of dura mater, the *falx cerebri* (fig. 615, 3), is seen dipping vertically in between the hemispheres of the brain along the line of the superior longitudinal sinus. This fold is narrow in front, where it is attached to the crista galli, but widens as it passes backwards, and is attached below and behind to the middle line of the great transverse process of dura mater which roofs in the inferior occipital fossæ (*tentorium cerebelli*—ib., 4).

Cut the falx from its attachments to the crista galli, divide the narrow anterior uncut portion of the dura mater and draw it backwards, severing the veins which pass from the brain surface into it, but leaving the roof of dura mater attached by its posterior undivided part.

Support the hind part of the brain with the left hand and allow the head to hang backwards. The frontal lobes of the cerebrum will separate from the anterior cranial fossa by their own weight, aided, if need be, by the fingers, or the handle of a knife, which may be required to raise the olfactory bulbs from the cribriform plate of the ethmoid.

Gently raising the brain from its bed from before backwards, cut the cranial nerves as they successively appear, so as to leave a recognisable portion of each attached to the brain, on the one hand, and at its aperture of piercing the dura mater on the other.

The **optic nerves**, seen on the inside of the anterior clinoid processes, are the first of these to be divided, and behind and internal to them are the **internal carotid arteries**. Next divide a conical membranous process, the **infundibulum**, which descends in the middle line behind and between the carotids to be attached to the pituitary body in the sella turcica.

Behind and outside the carotids the **third nerve** is to be cut on each side, and still farther outwards the small **Sylvian vein** which emerges from the Sylvian fissure of the brain and enters the dura mater beneath the lesser wing of the sphenoid. Now turn the head with the face to the right side, and gently raise the left temporal lobe of the cerebrum from the middle cranial fossa, thereby exposing the attachment of the tentorium along the superior edge of the petrous portion of the temporal bone. A fine white thread, the **fourth nerve**, which lies beneath the inner free edge of this fold of dura mater, is to be cut, and the tentorium is to be divided with the point of the knife along its bony attachment from the posterior clinoid process backwards to the posterior inferior angle of the parietal bone. Having then turned the head to the opposite side, the corresponding parts are to be divided, after which the head is to be brought back to the median plane. Divide on each side successively, the **fifth nerve** (behind and external to the posterior clinoid process, beneath the edge of the tentorium), the **sixth nerve** (internal to and below the fifth, upon the

clivus), the **seventh** and **eighth** (entering the internal auditory meatus), the **ninth** and **tenth** (which, together, pierce the dura mater over the posterior lacerate hole), and the **twelfth** nerve (which is divided into two bundles, and pierces the membrane over the anterior condyloid hole). The **eleventh** nerve, which can be seen on either side ascending from the spinal canal through the foramen magnum, should be left undisturbed on the right, but should be cut and removed with the brain on the left. In the foramen magnum the two vertebral arteries are visible, piercing the dura mater, and are next to be cut. Then by pushing the scalpel into the foramen magnum the spinal cord should be divided at the lowest point that can conveniently be reached, and, if necessary, the first pair of spinal nerves should also be divided. The fingers of the right hand being now slipped beneath the cerebellum and pons into the front of the inferior occipital fossa (the left having through the whole dissection supported the brain below), draw out the brain with the two hands and place it on a nest of cotton wadding in a shallow basin, and immersed in methylated spirit diluted with one third of water. After a week's immersion, remove from the brain as much of the investing membrane as may be easily taken off, and place it in undiluted spirit until the rest of the dissection is finished.

400. THE DURA MATER, a part of the skull wall rather than of its contents, is bluish-white, firm, and inelastic, consisting of lamellæ of closely interwoven white fibres, with a few elastic fibres intermixed. Blood-vessels and lacunar interspaces imperfectly subdivide the dura mater into two layers—an outer and an inner. The former is the endosteal, the latter is the meningeal layer. The outer surface of the endosteal layer is rough, as can be seen when a portion is floated in water; this is closely adherent to the sutures, to the edges of foramina, and to rough places on the bones, but elsewhere it is united to the bone by fine fibres and vessels, between which are patches lined by *epidural endothelium*, bounding *subendosteal lymph spaces*; but even here its exterior does not glisten like its inner surface. It is almost inseparable from the bone, both in the young growing skull of the child, and in extreme old age; and it is prolonged through the foramina to join the pericranium without. At the foramen magnum this layer is continued into the tissue of the occipito-atlantoid ligaments, and thereby into the vertebral periosteum.

The fibres of this layer are irregular in direction, but in the roof portion of the membrane they chiefly pass backwards and inwards, converging towards the median line.

401. MENINGEAL VESSELS.—The arteries which nourish the cranial bones are contained in this layer. In the anterior cranial fossa these meningeal arteries are branches of the anterior and posterior ethmoidals and internal carotids; in the middle cranial fossa and on the roof they are derived from the middle and small meningeal branches of the internal maxillary, and from the meningeal branches of the internal carotid and ascending pharyngeal. In the posterior fossa they arise from the ascending pharyngeal, vertebral, mastoid, and occipital arteries. These arteries have accompanying veins, which are usually of small size, except those of the middle meningeal. These latter veins end by escaping through the spinous foramen, and emptying their blood into the pterygoid plexus. The blood from the other vessels is collected in interspaces, which are sometimes irregular and cavernous, or else are definitely tubular and lined by a continuous endothelium. These larger venous channels collect and return all the blood from the brain, as well as from the membranes, and are called the **sinuses of the dura mater**. Each sinus is a tubular interspace between the outer or endosteal and the inner or meningeal layer of the dura mater.

The inner layer of the dura mater is glistening and smooth within and lined by a layer of endothelium, between which and the contiguous outer surface of the arachnoid or connective tissue envelope of the brain there is an extensive **subdural interspace**. These two layers, dura mater and arachnoid, although in contact, are only united around the veins which pass from the brain to the sinuses of the dura mater, or around villous processes of the arachnoid which project against, into, or through the dura mater, and which by their

enlargements make the corpora Pacchioni (p. 60). These warty projections are most common along the superior longitudinal sinus, either within or outside the dura mater, or else projecting into the cavity of the sinus. The fibres which make up the inner or meningeal layer of the dura mater run for the most part from behind and without forwards and inwards. In each layer there are lymph spaces between the fibres, those of the meningeal layer communicating with the subdural, those of the periosteal layer with the

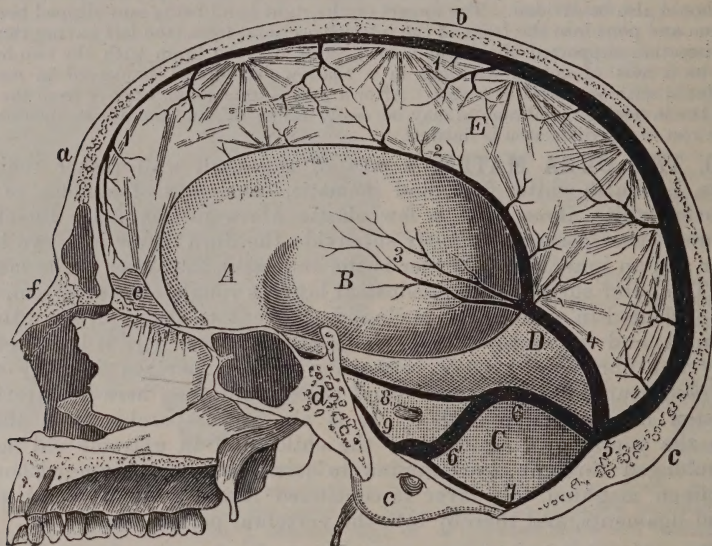


Fig. 616.—Sagittal section of skull, showing the falx cerebri (*E*) and median system of sinuses—*a*, frontal bone; *b*, parietal; *c*, occipital; *d*, basisphenoid; *e*, crista galli; *f*, nasal bone—*A*, dura mater of anterior fossa; *B*, same in middle fossa; *C*, posterior fossa; *D*, tentorium; *E*, falx—1, superior longitudinal sinus; 2, inferior longitudinal sinus; 3, venæ Galeni; 4, straight sinus; 5, torcular Herophili; 6, lateral sinus; 6', sigmoid sinus; 7, occipital sinus; 8, superior petrosal sinus; 9, inferior petrosal sinus.

epidural lymph spaces. The blood-vessels of the meningeal layer end in a fine stratum of capillaries, which often present varicosities, and which empty themselves into the sinuses.

The largest area of separation of the endosteal and meningeal layers is in the middle of the base of the skull. Here the former lamella is closely applied to the surface of the basilar process and to the back and sides of the basisphenoid, the apex of the petrous bone, the root of the alisphenoid, and the floor of the sella turcica, and it is separated from the meningeal layer by lacunar tissue lined by an irregularly distributed endothelium, making a great blood space, the cavernous sinus and its collateral dependencies. This spongy tissue is traversed on each side by the third, fourth, and sixth nerves, and the carotid artery, and medially by the pituitary body, over which the meningeal layer forms a shelf-like *pituitary diaphragm* with a central small hole for the infundibulum (fig. 617).

Outside this cavernous area of separation there is on each side a separate interspace (**Meckel's space**), wherein lies the Gasserian ganglion of the fifth pair of nerves (fig. 617). Still farther backwards and outwards there was a third interval at the aqueductus vestibuli in the early embryo, where the endolymphatic sac was interposed between the lamellæ (§ 537). The two layers can be traced through the optic foramen into the orbit (§ 516).

At the foramen magnum the meningeal layer finally separates from the periosteal and forms the **dura mater of the cord**, a cylindrical sac, which envelopes the cord and the origins of the nerves, and tapers below to a fine thread, which is lost on the periosteum of the coccyx. The fibres of this tube are chiefly longitudinal. It is pierced on each side by the anterior and posterior roots of the successive spinal nerves, each of which escapes by a separate hole and receives a delicate sheath from it. Outside the dura mater of the cord is a wide space containing plexuses of veins, fat and connective tissue, the homologue of the interdural spaces within the skull, not of the epidural lymph spaces.

Two sets of nerves have been traced into the dura mater. Fine non-medullated fibres from the cavernous plexus of the sympathetic and from the peripheral plexuses on the middle meningeal and other arteries supply the vessels. Recurrent branches from the three subdivisions of the fifth nerve are distributed to the cavernous area, and the meningeal branches of the hypoglossal supply the lateral sinus. Nerves ending in the membrane, apart from the walls of the vascular spaces, are not demonstrable.

402. PROCESSES OF DURA MATER.—The meningeal layer of the dura mater sends in processes which separate the interior of the cranial cavity into a series of communicating loculi for the different parts of the central nervous mass. There are three greater and five smaller partitions.

Falx cerebri, already seen (figs. 615, 3; 616), consists of two sets of radiating fibres which turn downwards from each side, to unite in the median plane as a sagittal partition between the cerebral hemispheres. These fibres are at first separated from each other by a longitudinal space, closed in above by the endosteal layer in the middle line, the superior longitudinal sinus (fig. 616, 1). The *convex* or upper edge of the falx is attached successively to the ethmoidal spine of the sphenoid, the crista galli of the ethmoid, the middle ridge of the frontal, the edges of the superior longitudinal sulcus of the parietals and squama occipitis; its free, *concave* or lower border overlies the corpus callosum in the longitudinal cerebral fissure, and is often irregular, and includes between its layers a small *inferior longitudinal sinus* (*ib.*, 4). The *base* of the falx behind is attached to the middle line of the tentorium, and includes the straight sinus.

The falx cerebri is not causal of, but consequential on, the cleavage of the cerebrum into two hemispheres.

The **tentorium cerebelli** (fig. 615, 4) is the crescentic septum cut through in taking out the brain, which stretched between the cerebrum above and the cerebellum below, but not in a horizontal plane, being highest at the front edge where it receives the concave edge of the falx, from thence sloping downwards both laterally and backwards, like the cloth of a tent, towards its convex border of attachment. This latter edge is fixed to the transverse ridge of the occipital bone behind, to the posterior inferior angle of the parietal laterally, to the edge of the petrous portion of the temporal bone in front, and is continued from this inwards by a fold, the *plica petro-clinoidea postica*, to the posterior clinoid process, internal to which it extends to join that of the other side in the median line.

In the periosteum under this median fold the ossified **dorsum sellæ** develops.

The anterior or concave edge of the tentorium is free, except medially, where it is attached to the base of the falx, and at each cornu, where it is prolonged as a fold, the **plica petro-clinoidea antica** over the end of the convex border to the anterior clinoid process (fig. 615, 5). The concave border of the tentorium forms the posterior and lateral boundary of a lanceolate **superior occipital foramen**, through which the crura cerebri, the superior cerebellar peduncles, the third and fourth nerves, and the basilar artery pass (fig. 617).

Falx cerebelli, a small vertical fold, which is often double, especially in

front, passes forwards and downwards along the inferior occipital crest between the lateral lobes of the cerebellum, from the tentorium to the hinder border of the foramen magnum.

The smaller folds of dura mater are the **sphenoidal folds** which project backwards from the hinder border of the lesser sphenoidal wings, the **lunulæ** which cross the optic nerves from the anterior clinoid processes inwards, and the **diaphragm of the pituitary body**.

403. MENINGEAL SINUSES, the venous spaces formed along the different lines of separation of the periosteal and meningeal layers of the dura mater, are cavities with a lumen which is scarcely alterable, and usually triquetrous.

Each is lined by a venous endothelium on a thin tunica intima which has externally a thin interrupted layer of elastic fibres. These special tissues are continuous into the corresponding layers of those veins which pass therefrom.

They have no valves, but are often crossed by endothelium-clad cords (**chordæ Willisii**), which are sometimes few and thick, and sometimes so

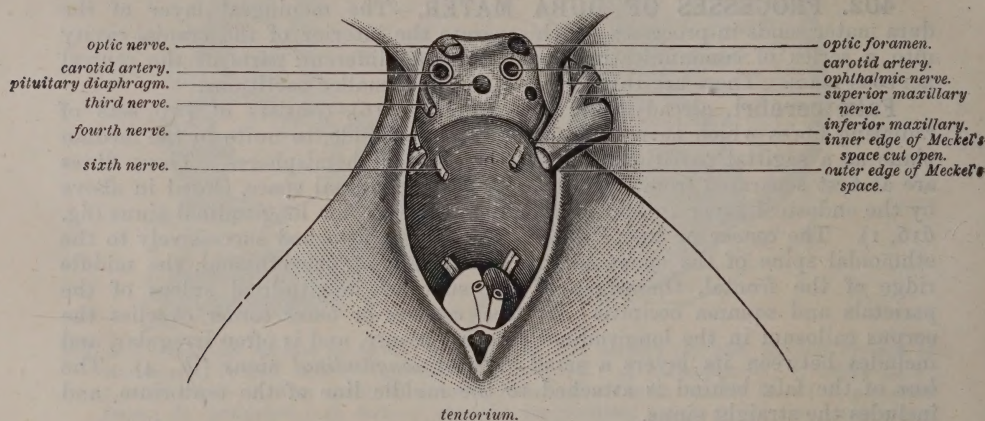


Fig. 617.—View of the superior occipital foramen and its boundaries, from above.

close and reticulated as to give to the sinus a spongy appearance. **Corpora Pacchioni** often project into these tubes. Eighteen such sinuses are described, six of which are single and median and six paired.

(1) The **superior longitudinal sinus** (fig. 616, 1), enclosed in the convex edge of the falx cerebri, begins at the foramen cæcum by a minute vein, foetally continuous with the nasal veins, but in the adult beginning only in the dura mater. It grooves the frontal bone, the conjoined sagittal edges of the parietals, and the squama occipitis, enlarging as it passes backwards, and receiving the superior cerebral and meningeal veins, often communicating with the superficial temporal veins through the parietal foramina. It most commonly ends behind by turning to the right, into the right lateral sinus.

(2) **Inferior longitudinal sinus** (fig. 616, 2), a cylindroid vein of small calibre, lies in the concave or lower edge of the falx cerebri, conveying blood from the inner surface of the cerebrum backwards. It usually dilates suddenly, without apparent cause, at its hinder sixth, and empties into (3) the **straight sinus** (*ib.*, 4), which is its continuation backwards in the base of the falx cerebri, where it is attached to the middle of the tentorium. Two large veins from the interior of the brain (*venæ Galeni—ib.*, 3) open into the point of union of the inferior longitudinal and straight sinuses. The straight sinus follows the slope of the middle of the tentorium to the internal occipital protuberance; here it

communicates by a narrow passage with the ending of the superior longitudinal sinus, and turns leftwards into the left lateral sinus. The straight sinus receives on each side two superior cerebellar veins and two posterior inferior cerebral veins.

Torcular Herophili.—The mode of union of the superior longitudinal and straight sinus is variable, but it is rare to find them uniting into a central sac. When such exists, it is named torcular Herophili, but this name is sometimes given to any mode of union of the veins at this spot.

(4) **Lateral sinuses** are large horizontal canals included in the hinder attached border of the tentorium and grooving on each side the occipital bone and the posterior inferior angle of the parietal. Here, in their archaic foetal condition, they communicated through the post-glenoid foramen with the primitive external jugular vein, but this connection early diminishes, and is ultimately represented only in rudiment by the mastoid vein; an originally small channel of communication from the lateral sinus to the posterior lacerate foramen becomes commensurately dilated, and appears in the adult as its continuation—(5) the **sigmoid sinus** (fig. 616, 6'). This passes downwards, and having left the tentorium, grooves the mastoid portion of the temporal bone, after which it turns forwards and inwards, indents the upper surface of the exoccipital, and ends in the foramen lacerum posterius. The sigmoid sinus is oval in section, and receives the superior petrosal sinus at the point where it arises from the lateral sinus. Its course should be carefully noted, that it may be avoided in the operation of trephining the mastoid antrum.

The jugular foramen is subdivided into three parts by intra-jugular processes of fibrous tissue or of bone: the sigmoid sinus and posterior meningeal artery pass through the hindmost of these; the ninth, tenth, and eleventh nerves pass through the middle, and the inferior petrosal sinus and the meningeal branch of the ascending pharyngeal artery pass through the foremost part.

It will be observed that one lateral sinus is larger than the other; one, usually the right, conveys chiefly the blood of the superior longitudinal sinus, that is, of the brain periphery and skull wall, the other principally that of the straight sinus, or that of the central ganglionic masses of the brain.

(6) The **cavernous sinus** is the spongy interval between the meningeal and periosteal lamellæ of dura mater on each side of the basi-sphenoid. Its outer wall is firm and contains in its layers the third, the fourth, and the ophthalmic

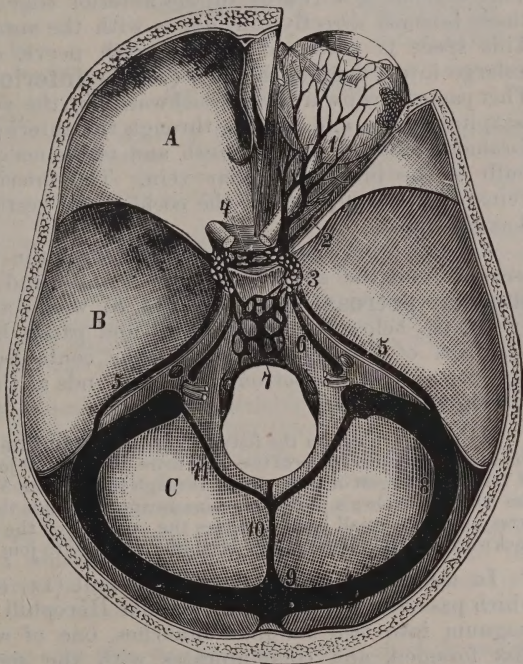


Fig. 618.—Venous sinuses at the base of the skull—A, anterior fossa; B, middle fossa; C, posterior fossa; 1, ciliary veins; 2, external ophthalmic vein; 3, cavernous sinus; 4, optic nerve; 5, superior petrosal sinus; 6, inferior petrosal sinus; 7, transverse basilar sinus; 8, lateral sinus; 9, torcular Herophili; 10, occipital sinus.

division of the fifth nerve, the last passing forwards and upwards from Meckel's space. Above the third nerve it receives a vein from the sphenoidal fold of dura mater, (7) the **sinus alæ parvæ**. The inner wall of the cavernous sinus is practically non-existent as a distinct lamella; the internal carotid artery, the sixth nerve and cavernous plexus of the sympathetic lie internal to the principal part of the space and form a sort of inner wall, but above and below the carotid artery the spongy tissue continues inwards from side to side, both in front and behind the dorsum sellæ. In front of the dorsum sellæ and beneath the pituitary diaphragm, the cavernous tissue surrounds the pituitary body, in front, below, and behind. The definite (8) **circular sinus**, sometimes described as engirdling the hypophysis, is artificially limited, the spongy, blood-holding tissue being continuously pre-, post-, and sub-pituitary.

It is desirable to dissect the cavernous sinus on one side only at present, reserving the other until the orbital nerves are being traced.

Behind the dorsum sellæ the two cavernous sinuses also unite in a large-meshed lacunar sinus, (9) the **basilar plexus** or sinus, which underlies the dura mater and covers the whole extent of the occipital clivus (fig. 618, 7). This extends downwards to the anterior edge of the foramen magnum, and there becomes directly continuous with the anterior veins of the spinal canal. This space is traversed by the sixth nerve, external to which the lacunæ enlarge into a definite channel, (10) the **inferior petrosal sinus** (fig. 616, 9). This passes downwards and backwards in the sulcus which overlies the petro-occipital suture, and, passing through the anterior part of the posterior lacerate foramen, internal to the ninth and tenth nerves, empties its blood into the bulb of the internal jugular vein. The inferior petrosal sinus receives the veins of the aqueducts of the cochlea and vestibule as well as the vein of the floccular fossa.

Several other channels exist whereby the blood of the cavernous sinus escapes from the skull, the most definite and primitive of these is (11) the **superior petrosal sinus** (fig. 618, 8), which arises from the cavernous sinus externally, below the fourth nerve, and passes backwards and outwards above the neck of Meckel's space and the contained fifth nerve; it grooves the superior edge of the petrous bone, and ends at the angle of union of the lateral and sigmoid sinuses.

This spot of union in the foetus is called the **confluens lateralis**. Several branches of the cavernous sinus traverse the skull more directly and join the extra-cranial pterygoid plexus of veins, the largest of these passes through the foramen Vesalii, or, when that canal is absent, the foramen ovale; a plexus of veins escapes through the carotid foramen, surrounding the artery, and one small branch pierces the cartilage of the anterior lacerate foramen, and runs backwards in the inferior petro-occipital cartilage to join the jugular bulb.

In the falx cerebelli there is a small (12) **occipital sinus** (fig. 618, 10), which passes upwards to the torcular Herophili and divides near the foramen magnum into two *marginal* branches, one of which passes to either side of that foramen, and communicates with the sigmoid sinus, near the jugular foramen. Sometimes this vessel is double, and it often communicates with the spinal veins.

404. EMISSARY VEINS traverse the cranial bones, uniting the intra- and extra-cranial veins, but they are singularly inconstant: the post-glenoid rudiment of the primitive vein is one of the most important of these, but it is supplanted by the internal jugular vein. There are also on each side the parietal vein of Santorini, the posterior condyloid vein, the anterior condyloid vein around the hypoglossal nerve, and the occipital, which join the lateral sinus and the occipital vein.

In the diploë of the cranial bones there are large, branched vascular canals, with imperfect walls; these are for the accommodation of the diploic veins (fig. 619), which are thin-walled and valveless, and arranged in five sets—(1) **frontal**, which communicate with the supraorbital veins; (2) **fronto-sphenoidal**, which communicates with the sinus alæ parvæ; (3) **fronto-**

parietal, receiving a branch from either side of the coronal suture, and ending in the superior petrosal sinus; (4) **external parietal**, receiving blood from the diploë about the temporal crest and ending at the mastoid foramen; (5) **parieto-occipital**, ending in the lateral sinus. Of the meningeal arteries the middle alone has two companion veins, one of which usually receives the Sylvian vein from the brain surface.

Dissection.—As by this time the body is about to be turned on its face, and as in a few days the dissector of the arm will desire to have its brachial plexus accessible, the further dissection of the head should be postponed and that of the neck proceeded with. Accordingly, the interior of the cranial cavity is now to be filled with tow or cotton wadding soaked in the preserving fluid, over which the cap of dura mater is to be drawn; the bony skull-cap is to be replaced and covered by the flaps of scalp, which should be carefully stitched together. The mouth and nostrils should also be filled with cotton wadding steeped in the antiseptic, and the lips should be stitched together. A pad of similarly prepared material is to be laid over each eye, and the upper part of the head should be swathed in a bandage soaked in the same fluid and covered with waterproof for the present.

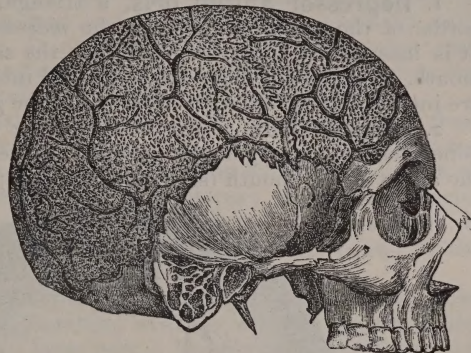


Fig. 619.—Veins of the diploë shown by removing the outer table of the skull.

405. THE NECK.—Dissection.—

Divide the skin (1) along the front edge of the *sterno-mastoid* muscle from sternum to skull; (2) along the clavicle; and (3) along the median line from the lower lip to the sternum. Continue this incision above along the red margin of the lip, around the angle of the mouth to the median line of the upper lip, and from thence to the inner canthus, skirting the ala of the nose. Reflect the posterior flap backwards, and the anterior upwards.

The skin of the neck is thin and elastic, with few hairs, but it becomes thicker and more closely bound down in the face where the dissection requires much care, and the keeping of the edge of the knife close to the skin, through which, in the male, the follicles of the beard-hairs (the coarsest in the body, which in section measure 0·1 in their long diameter) sink into the subjacent muscular tissue. Subcutaneous fat is variable in amount, but most copious beneath the chin; it should be carefully cleared away to expose the subjacent muscular sheet. The beard-hairs in the male average about 21 to the sq. cm.

406. PLATYSMA (fig. 614) a pale, thin, and variable muscular expansion, arising from the skin over the ramus and body of the lower jaw, beginning at the chin where the fibres are connected to their fellows of the opposite side. Very few are attached to the bone directly, but many arise from the surface of the inferior labial muscles; the hindmost fibres arise on a higher level from the fascia and skin over the *masseter* and parotid. The fibres descend outwards, slightly diverging, and form a continuous sheet, which is inserted into the fascia over the *pectoral* and *deltoid* muscles. The platysma crosses the clavicle and acromion, and lies superficial to all other structures in the neck.

A few fascicles of its upper portion arise from the tissues about the angle of the mouth, and radiate thence backwards towards the parotid fascia. These constitute the *musculus risorius*. The middle strip of the neck lies uncovered between the borders of the *platysma* of the two sides.

The *platysma* is an undifferentiated extension downwards of the facial muscle-layer, and is supplied by the inferior bucco-labial and cervical branches of the facial nerve (fig. 614), which should now be sought for (p. 577). In lower animals it becomes continuous below with the thoracic part of the cutaneous muscle of the trunk (*panniculus carnosus*), which is a superficial lamellar dismemberment of the ventral muscle. It is incorrect, however, to regard the *platysma* as especially the remains of the panniculus, which in each region is segmented from the local ventral musculature.

Sphincter Colli.—Below the chin there are frequently a few cross muscular slips decussating and lying beneath the fibres of the *platysma*. These are continuous with the second layer of facial muscular fibres. When well developed they constrict the submental

fat and give rise to the appearance of double or multiple chin. They are also supplied by the facial nerve.

407. MOUTH MUSCLES.—Around the margin of the mouth there are two planes of muscular fibres more or less connected with the oral attachment of the *platysma*. These are split up into a series of separately acting bands, to which the lips owe much of their mobility. The superficial series consist of:—

1. **Depressor anguli oris**, a triangular muscle arising from the lower border of the mandible between the *masseter* muscle and the mental foramen. It is inserted by a narrow band into the skin and mucosa at the angle of the mouth. Some of its fibres are continued into the upper lip. Its fibres of origin are inseparably mixed up with those of the *platysma*.

2. **Zygomaticus**, a flat band arising from the outer part of the malar bone, close to the zygomatic suture. Descending forwards, it is inserted into the angle of the mouth (skin and mucosa); some fibres being continued into

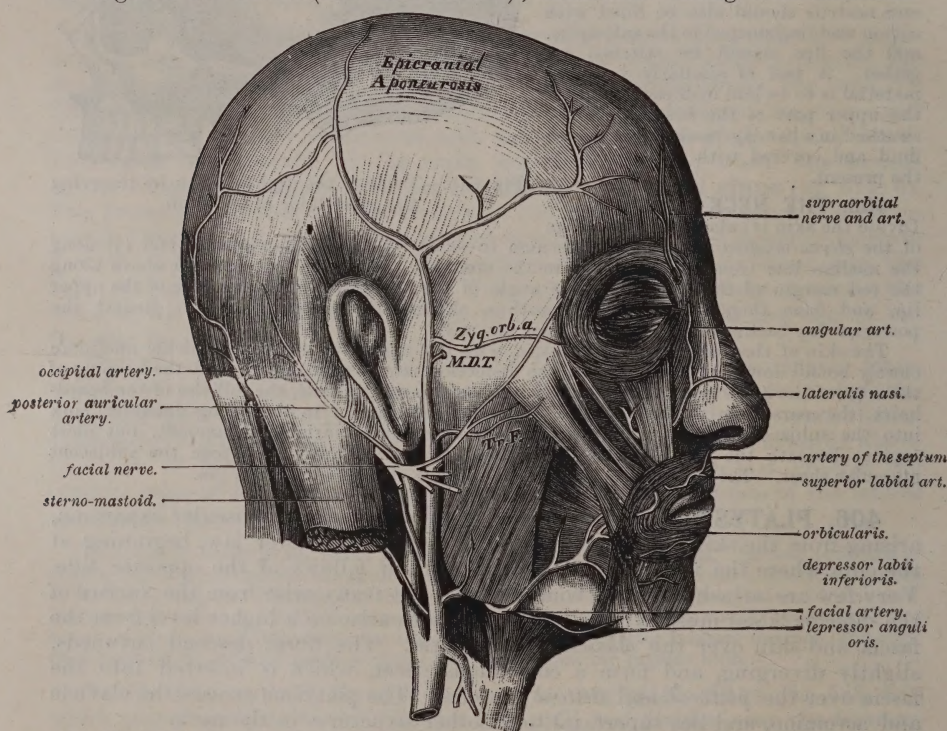


Fig. 620.—View of superficial muscles and vessels of the side of the face—*M.D.T.*, middle deep temporal artery; *Tr.F.*, transverse facial artery.

each lip. This muscle is usually single (fig. 614), but may be split into fascicles (fig. 620); a small upper detached band is described as *zygomaticus minor*, but is not usually present.

More frequently a parallel slip arises from the *orbicular muscle* of the eyelid, and is called the *orbicular zygomatic*. The *zygomatic* crosses the buccal fat and the facial vessels. The fibres of the *risorius* usually lie between it and the *depressor anguli oris*. Branches of the facial nerve can be traced into the hinder edge of each muscle.

3. **Levator labii superioris** (fig. 620) is a quadrate, indefinitely bordered muscle, arising above from the nasal process of the maxilla and from the bony infraorbital margin, and inserted below into the upper lip, and the neighbouring part of the ala of the nose.

This muscle, like the last, is frequently fasciculated. Its infraorbital origin is overlapped by the *orbicular* muscle of the lids, and it covers the infraorbital nerve and vessels, the *compressor nasi*, and the fibres of the second stratum. When segmented, its inner part is called *levator labii superioris alaeque nasi*, and its outer, *levator labii superioris proprius*. Divide these muscles near their origins and carefully reflect them towards the mouth.

The second stratum of muscles beneath these consists of four parts :—

1. **Depressor labii inferioris** is quadrate, but with very indefinite margins. Some of its fibres are branched, and they are sometimes mixed with a greyish fatty connective tissue. It arises from the mandible below and internal to the mental foramen; its fascicles ascend internally and end in the substance of the lower lip; it is overlapped by the *triangularis*.

2. **Levator anguli oris**, beneath the *levator* of the upper lip, arises from the floor of the canine fossa, and, narrowing, descends outwards to be inserted into the angle of the mouth, especially on the mucous side, and by a thick fascicle into the substance of the lower lip. A small part of its outer border appears superficially between the *levator labii superioris* and the *zygomatic*. It is crossed by the labial and nasal branches of the infraorbital nerve, and by the facial artery.

3. **Buccinator**, the largest muscle of the series, cannot be seen until a later stage of the dissection. Its fibres of insertion, however, can be traced into the lip of whose musculature they form a large part. The fibres of the upper part of this muscle chiefly pass into the lower lip, and those of the lower part into the upper lip. These bucco-labial fascicles pass in the thickness of the lips towards the middle line and are lost in the connective substance within the lips, but are not attached to the skin or mucous membrane, as are the similarly prolonged fibres of the foregoing muscles.

The labial musculature is supplemented by the following muscles :—1. **Museculus labii proprius** (fig. 639, 4), a series of scattered oblique fibres which pass, especially in the lower lip, from the deep surface of the skin to the mucous membrane through the thickness of the lip. These fibres are closely set and well developed in the suckling, but more scattered and consequently less conspicuous in the larger lips of the adult, as they do not increase commensurately with the growth of the lip.

2. **Museculus incisivus**, superior and inferior, two sets of fibres on each side, arising from the juga alveolaria of the lateral incisor teeth in either jaw and passing towards the angles of the mouth to be there lost in the deep surface of the muscular interlacement (fig. 640). A supplementary but scarcely separate slip in the upper jaw arises from the maxilla close to the nasal spine, and has been described as *naso-labialis*.

The course of the several labial fibres cannot be followed by simple dissection, but becomes clear on the examination of a series of successive sections. There is no special *orbicularis oris* of purely sphincter fibres, but in each lip there are several strata of fibres derived from the various sources already mentioned (fig. 640). Those from the *buccinator* usually remain intermediate, those for the *musculi incisivi* make the so-called inner stratum of the *orbicularis*. This arrangement enables the lips to close, to be closely applied to the alveolar arch and to assume many varieties of shape without puckering.

Into all these muscles branches of the facial nerve can be traced (§ 456).

A detached band of the *musculus incisivus inferior* passes downwards and forwards through the soft parts from the lower incisive alveoli to the skin of the chin, which it can elevate, and is hence called *levator menti*, a similar wandering slip of the *superior incisive* muscle is inserted into the ala of the nose and forms a *depressor alae nasi*.

Dissection.—Divide and reflect the *platysma* from below upwards, clearing the surface of the deep fascia, the superficial nerves, and the external jugular vein. In certain cases of cerebral and other diseases, it was formerly the practice to open this vessel as it descends on the *sterno-mastoid*. In doing so, the surgeon was instructed to cut across the fibres of *platysma* so as to ensure a gaping wound and a copious stream of blood.

408. THE CERVICAL FASCIA is a fibrous expansion of very variable strength in different parts of the neck. In the nuchal triangle it constitutes the sheaths of the muscles of the back, and can only be made to appear as an independent expansion by a system of artificial dissection. From the outer border of the *trapezius* it is continued forwards as a rather lax areolar layer,

in which many lymphatic glands are embedded, pierced by the cutaneous nerves and only attaining the definiteness of a true fascia as it approaches the upper edge of the clavicle and the hinder border of the *sterno-mastoid*. Along the latter it splits into two lamellæ, which enclose that muscle. The **supra-sterno-mastoid layer** covers the sterno-mastoid muscle, unites with part of the deeper lamella along its inner margin (except for 2 cm. above the sternum), and from thence passes inwards to join its fellow medially, being attached above to the body of the jaw and to the zygoma. The **substerno-mastoid layer** covers the *scaleni* muscles and splits into two at the outer side of the great cervical vessels: the deeper of these is named the **post-pharyngeal layer**. The layer which passes in front of the vessels again divides into three lamellæ—one, keeping close to the *sterno-mastoid*, completes its sheath by joining the overlying layer. A second or **pretracheal layer** passes inwards behind the group of depressor muscles of the hyoid, and a third, which completes the sheath of the vessels, dips behind the thyroid body internal to the carotid artery, to join the deepest or **post-pharyngeal layer**, which lies behind the vessels. This last layer is continuous in the median plane behind the pharynx with its fellow of the opposite side. There is usually a separate deeper **prevertebral layer** sheathing the deep muscles of the vertebral column. The sympathetic nerve lies between this and the post-pharyngeal layer.

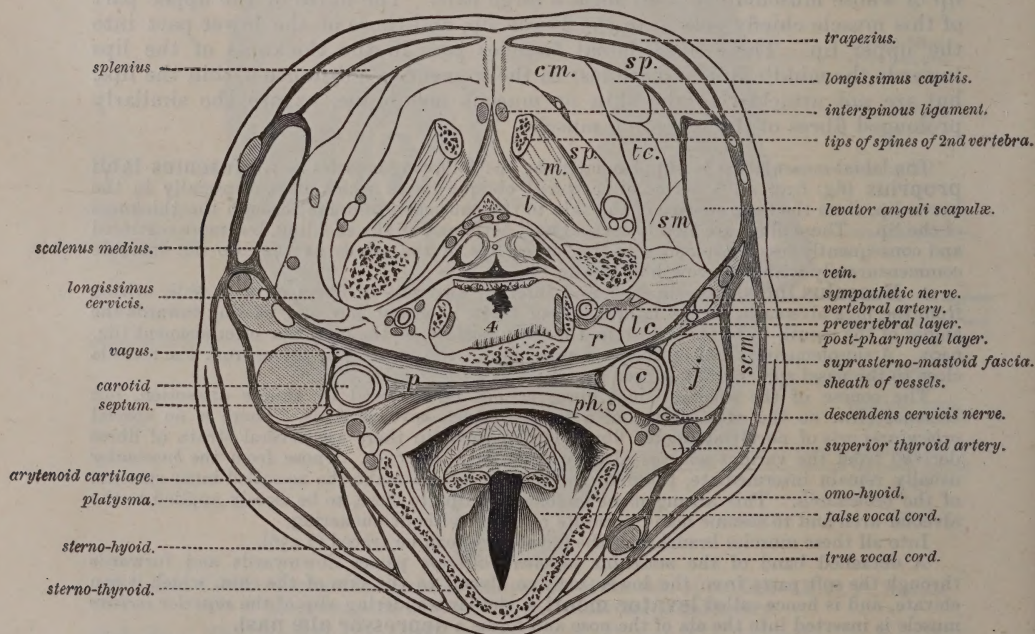


Fig. 621.—Horizontal section across the neck on the level of the intervertebral substance between the 3rd and 4th cervical vertebrae—*sp*, splenius; *cm*, complexus; *sp'*, semispinalis colli; *sm*, sterno-mastoid; *ph*, pharynx; *c*, carotid artery; *j*, jugular vein; *l. c.*, longus colli; *r.*, rectus capitis anticus major; *t. c.*, longissimus cervicis; *sm*, scalenus medius. The cervical fascia is represented by a thick shaded line.

The cervical fascia thus bounds one median and two lateral great vertical loculi in the neck—(1) the **muscular loculus** or sheath of the *sterno-mastoid* on each side; (2) the **perivascular sheath** or that of the vessels behind the last; and (3) the middle or **visceral loculus**, wherein are contained the trachea

ficially, covering the sterno-clavicular joint; the clavicular fibres are more vertical and deeper, but the degree of separability is variable. The muscle narrows in its mid-part, but flattens upwards towards the head. The sternal portion is inserted into the border of the mastoid process, into the mastoid bone behind the process, and into a variable amount of the outer part of the superior nuchal line. The clavicular fibres are inserted by a definite tendon into the mastoid process near its tip.

Each *sterno-mastoid* rotates the head to the opposite side or abducts it; both can draw it backwards. The head being fixed, they can elevate the sternum in forced inspiration. The muscle is supplied by the spinal accessory nerve which passes through it, and by branches of the second and third cervical nerves, and is nourished by branches of the suprascapular, superior thyroid, occipital and external carotid arteries.

Besides the *sterno-masto-occipital* or strongest portion, and the deeper *cleido-mastoid* portion, there is usually also a third set, of *cleido-occipital* fibres constituting the outmost portion

of the muscle, and passing from the clavicle to the nuchal line between the first portion and the *trapezius*. This slip is an anterior dismemberment of the *trapezius*, to which it is linked by innervation, and therefore is a muscle of the shoulder girdle; consequently the hinder edge of the *sterno-mastoid* and the anterior edge of the *trapezius* are apt to be variable in relative extents.

The *sterno-mastoid* rests on the sterno-clavicular joint, and the substerno-mastoid layer of its sheath, on the superior cervical lymphatic glands, the *omo-hyoid* and *sterno-hyoid* muscles, the sheath of the great vessels, cervical plexus, the *levator anguli scapulae*, *splenius*, *scaleni*, and *digastric* muscles, the occipital artery and the spinal accessory nerve. The *sterno-mastoid* is genetically connected to the *trapezius*, and is a dismemberment of that remarkable viscerally-innervated sling muscle of the shoulder girdle (§ 143). They originally formed an upper and inner sling for the girdle, but the muscular sheet has been extended downwards and is below fused with the superficial layer of the ventral muscle. The dorsally arising part of the *trapezius* and its derivative, the *rhomboid*, are for the most part true somatic muscles and have consequently a spinal innervation.

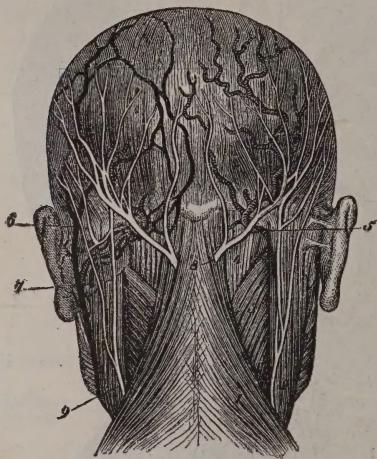


Fig. 623.—Posterior surface of nuchal triangle of neck dissected—1, trapezius; 2, sterno-mastoid; 3, splenius; 4, complexus; 5, occipital artery; 6, posterior auricular vein; 7, occipital vein; 8, greater occipital nerve; 9, lesser occipital nerve.

the clavicle below, the *trapezius* behind, and the median line in front, and is divided by a line drawn from the interval between the two heads of the *sterno-mastoid* to the mastoid process (the *sterno-mastoid line*) into the anterior and posterior triangles. Each of these is again subdivided by the *omo-hyoid* muscle into a superior and an inferior part.

The posterior superior triangle.—A rather irregular space is bounded behind by the edge of the *trapezius*, in front by the *sterno-mastoid*, and below by the *omo-hyoid*. By removing the loose connective tissue into which the cervical fascia is here resolved, the following parts are exposed :—

(1) The posterior cervical lymphatics, glands and vessels (fig. 622), (2) the cervical plexus, (3) the spinal accessory nerve, (4 and 5) the transverse and superficial cervical vessels below, (6) the occipital artery above, and (7) the upper part of the brachial plexus. The floor of this space is formed by the *scaleni*, *splenii*, and *levator anguli scapulae* muscles.

410. TRIANGLES OF NECK.—The quadrilateral space on each side of the neck is bounded by the lower jaw above,

The posterior cervical lymphatics (fig. 622) stream downwards from the head in two series; one from behind the ear forms a set of three post-auricular glands over and in front of the mastoid process, communicating with the efferent lymphatics from the two small occipital glands which overlie the *trapezius* and ending in four superficial cervical glands along the hinder border of the *sterno-mastoid*. A second series descend backwards from the temporal and maxillary region, crossing the muscle to end in the lowest of these glands along its hinder

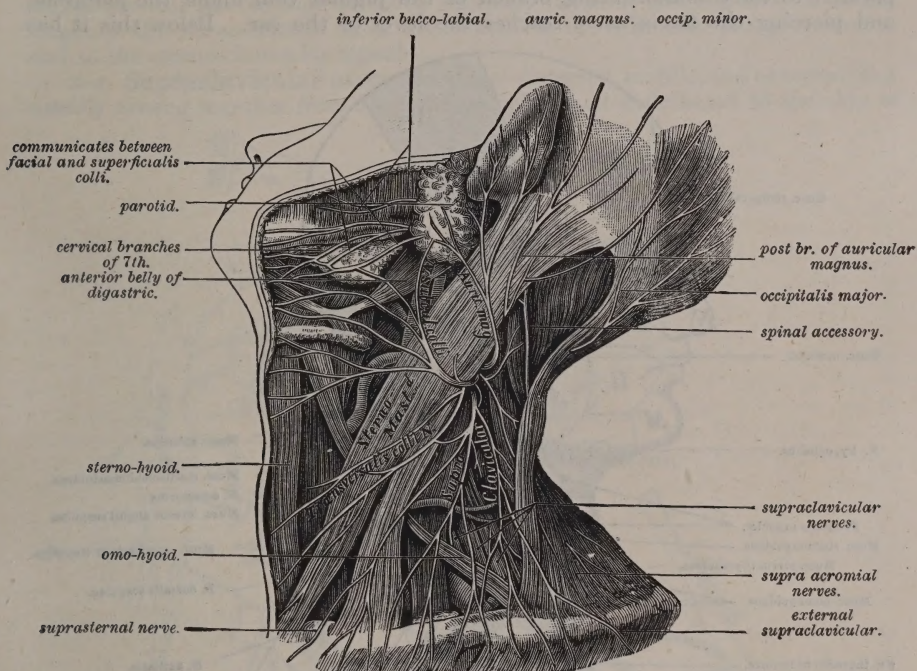


Fig. 624.—Superficial branches of the cervical plexus.

border. These glands are liable to become enlarged in diseases of the scalp and in strumous subjects; their efferent vessels pass behind the external jugular vein, and dip underneath the posterior edge of the *sterno-mastoid*.

411. THE CERVICAL PLEXUS OF NERVES (figs. 624, 626), whose superficial branches overlie the *sterno-mastoid*, can be exposed by tracing these backwards under the hinder edge of that muscle. It is formed by the looped unions of the anterior branches of the four upper cervical nerves, is overlapped by the *sterno-mastoid*, and lies on the *splenius*, *scalenus medius*, and *levator anguli scapulae*. The branches may be divided into three series:—1, cutaneous; 2, muscular; and 3, communicating.

The cutaneous nerves are ascending and descending. The former are three:—

1. **Occipitalis minor** (figs. 614, 624), derived chiefly from the second cervical, ascends on the *splenius* along the hinder margin of the *sterno-mastoid* to the scalp, where it terminates by dividing into anterior and posterior branches, distributed respectively to the skin over and above the mastoid process, and to the skin over the asterion as high as the parietal eminence (fig. 625, *OMi*). In the neck it gives off three fine branches, one, which is constant, to the skin

along the hinder edge of the *sterno-mastoid*, the other two only arise when this nerve has a root from the third cervical, and one of these is distributed to the skin over the *trapezius*, and the second communicates with the spinal accessory nerve. This nerve is the most variable branch of the plexus.

2. **Auricularis magnus** (fig. 614), the largest branch of the plexus, arises from the loop between the second and third cervical nerves, and winds round the hinder edge of the *sterno-mastoid* ascending on its outer surface behind, and parallel to the communicating branch of the jugular vein under the *platysma*, and piercing the fascia as it reaches the level of the ear. Below this it has

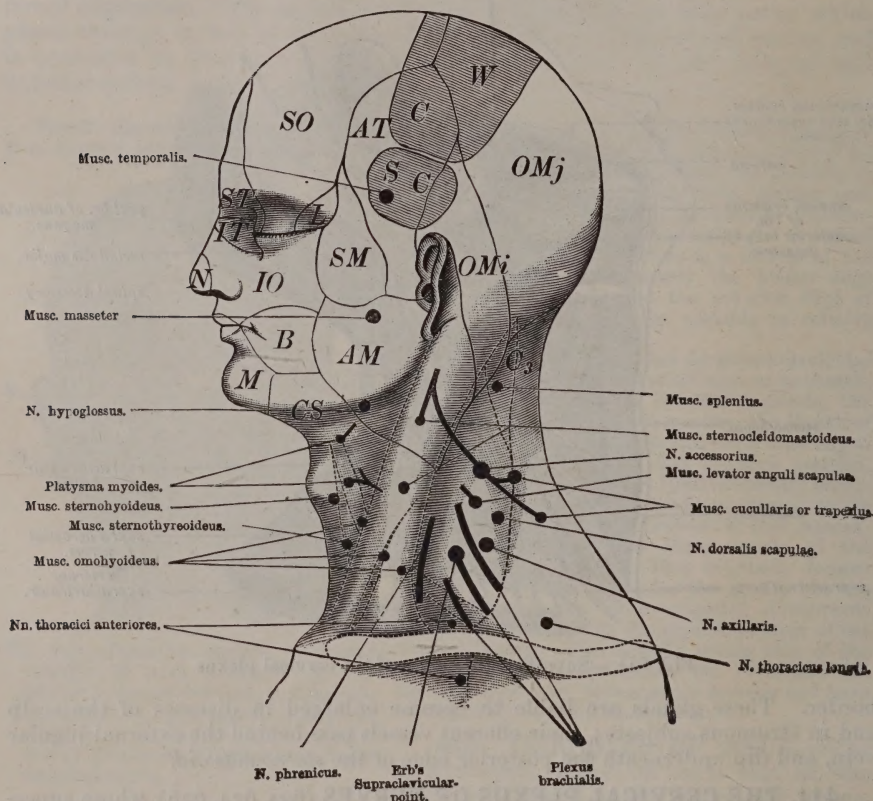


Fig. 625.—Areas of cutaneous distribution of sensory nerves and spots where stimulation produces reflex contractions of cervical muscles—SO, supraorbital; AT, auriculo-temporal; ST, IT, supra- and infratrochlear; N, nasal; IO, infraorbital; B, buccal; M, mental; OMj, occipitalis major; CS, superficialis colli; C W, area of opercular lobe of cerebrum; S C, speech centre.

divided into two branches, a smaller anterior which ramifies in the skin over the parotid, *masseter*, and the concave surface of the auricle, and from which fine branches pass to the gland; the larger posterior branch is distributed in auricular, mastoid, and post-temporal branches to these regions of the head (fig. 625, AM).

3. **Superficialis colli**, a small flattened nerve (fig. 624) arising from the third cervical, emerges below the last from under the hinder border of the *sterno-mastoid*, which it crosses, passing inwards under the jugular vein, to which it gives filaments, and finally dividing into ascending and descending

branches (fig. 614); the former pass upwards and inwards to form two loops with the inframaxillary branches of the facial nerve (fig. 624); the latter (transversalis colli) are distributed to the skin over the larynx and trachea, as far downwards as the sternum.

The cutaneous descending branches are five, which usually arise from one or more common stems.

1. **Suprasternal** (fig. 624) arises from the loop between the third and fourth cervical nerves, and descends obliquely inwards, crossing the clavicular origin of the *sterno-mastoid* to be distributed to the skin over the presternum, and to the sterno-clavicular capsule.

2-4. **Supraclavicular** nerves are three—internal, middle, and external (*ib.*), usually arising together from the fourth cervical, and distributed to the skin of

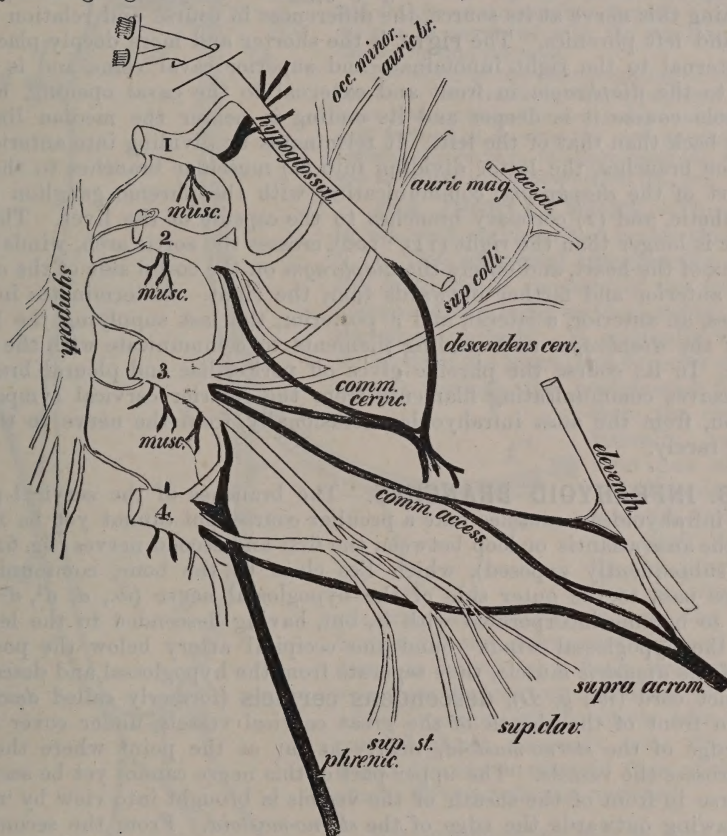


Fig. 626.—Plan of the cervical plexus and its connections. The motor branches of the plexus are represented by black lines.

the thoracic wall as far down as the fourth rib; the middle nerve not uncommonly pierces the clavicle.

5. **Supra-acromial** is a small branch which crosses the anterior edge of the *trapezius* to the skin over the point of the shoulder. It usually communicates with the spinal accessory nerve.

The vertebral muscular branches are mostly on a deeper plane and cannot yet be fully seen (fig. 626). They supply the *rectus capitis anticus minor* and *rectus lateralis* (first

cervical), the *rectus capitis anticus major* (first, second, third, and fourth), the *cervical intercostals* and *longus colli* (second, third, and fourth), *levator anguli scapulae* (second and third), *scalenus medius* (third and fourth), and *scalenus anticus* (fourth). The filaments from each cord usually pass separately to their distributions.

412. THE PHRENIC cannot yet be followed. It chiefly arises from the fourth cervical, with a few filaments from the third, and descends obliquely inwards across the *scalenus anticus* and over the first stage of the subclavian artery, crossing over the internal mammary as it enters the thorax behind the subclavian vein, the sterno-clavicular joint, and the cartilage of the first rib. It descends on the pericardium beneath the pleura in front of the root of the lung to the *diaphragm*, to which it is distributed. The thoracic course of this nerve has been elsewhere described (p. 315), but it may be well to note while examining this nerve at its source, the differences in course and relation of the right and left phrenics. The **right** is the shorter and more deeply placed; it lies external to the right innominate and superior caval veins, and is distributed to the *diaphragm* in front and external to the caval opening, but for its whole course it is deeper and its ending is nearer the median line and farther back than that of the left. It terminates by dividing into anterior and posterior branches, the latter dividing into (1) muscular branches to the lumbar part of the *diaphragm*, communicating with the phrenic ganglion of the sympathetic, and (2) coronary branches to the capsule of the liver. The **left** phrenic is longer than the right (115 : 100), crosses the aortic arch, winds round the apex of the heart, and enters the *diaphragm* on the costal side of the central leaflet, anterior and farther outwards than the right. It terminates in three branches, an anterior, a lateral, and a posterior, the last supplying the hinder part of the *diaphragm* and sending filaments to communicate with the cœliac plexus. In its course the phrenic gives off pericardiac and pleural branches, and receives communicating filaments from the inferior cervical sympathetic ganglion, from the *ansa infrahyoidea* occasionally, from the nerve to the *subclavius* rarely.

413. INFRAHYOID BRANCHES.—The branches of the cervical plexus to the infrahyoid muscles take a peculiar course, but cannot yet be traced. From the *ansa atlantis* or loop between the first and second nerves (fig. 627, *b*—to be subsequently exposed), which lies close to the bone, communicating branches pass to the outer side of the hypoglossal nerve (*ib.*, *d*, *d*¹, *d*²), and appear to become incorporated with it, but, having descended to the level at which the hypoglossal winds round the occipital artery below the posterior belly of the *digastric* muscle, they separate from the hypoglossal and descend as a distinct cord (*ib.*, *g*, *D*), **descendens cervicis** (formerly called *descendens noni*), in front of the sheath of the great cervical vessels, under cover of the inner edge of the *sterno-mastoid*, nearly as far as the point where the *omo-hyoid* crosses the vessels. The upper part of this nerve cannot yet be seen, but its course in front of the sheath of the vessels is brought into view by raising and drawing outwards the edge of the *sterno-mastoid*. From the second and third cervical nerves two small threads, the *communicantes cervicis* (*ib.*, *e*, *f*), descend inwards, separately or united on the outer side of the sheath of the vessels, usually crossing the internal jugular vein (but sometimes passing behind it), and these join the *descendens cervicis*, forming with it a loop (*ansa infrahyoidea*) in front of the sheath of the vessels. From this loop four branches arise, one to the anterior belly of the *omo-hyoid*, one to the *sterno-hyoid*, one to the posterior belly of the *omo-hyoid*, and one to the *sterno-thyroid*, which occasionally gives off a communicating twig to the phrenic.

The other communicating branches of the cervical plexus are twofold :—(1.) Separate branches from each nerve pass to the superior cervical sympathetic

ganglion; these cannot yet be followed (fig. 626). (2) Two branches communicate with the spinal accessory; these arise from the loops between the second and third, and the third and fourth nerves, the upper enters the *sternomastoid* and unites with the spinal accessory within it, the lower usually crosses the posterior superior triangle to the *trapezius*, under or in front of which it unites with the spinal accessory, and is distributed with it to that muscle, especially to its lowest part.

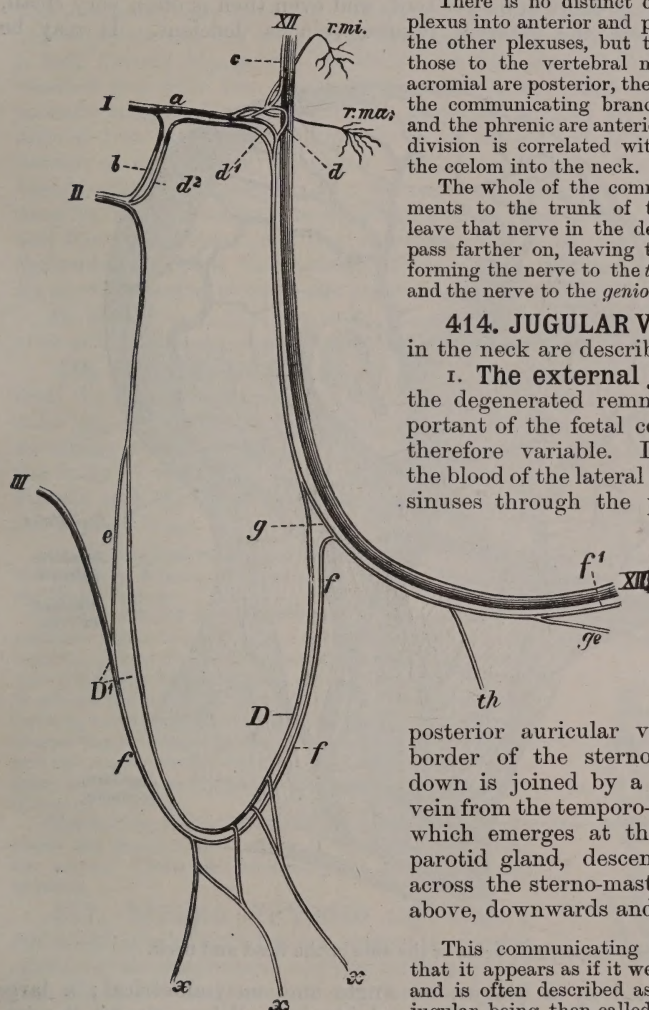


Fig. 627.—Plan of the infrahyoid branches of the cervical plexus accompanying the hypoglossal nerve. *I.*, *II.*, *III.*—first, second, and third cervical nerves; *c.*, ascending branch.

pierces the cervical fascia, and ends by joining the subclavian vein. It is accompanied by branches of the great auricular and lesser occipital nerves, and is crossed by the superficial cervical nerve.

There is no distinct division of the cervical plexus into anterior and posterior branches as in the other plexuses, but the occipital, muscular, those to the vertebral muscles and the supra-acromial are posterior, the other cutaneous nerves, the communicating branches to the hypoglossal and the phrenic are anterior, but this want of subdivision is correlated with the non-extension of the coelom into the neck.

The whole of the communicating cervical filaments to the trunk of the hypoglossal do not leave that nerve in the descendens cervicis, some pass farther on, leaving the cord anteriorly, and forming the nerve to the *thyro-hyoid* (fig. 627, *th*), and the nerve to the *genio-hyoid* (*ib.*, *ge*).

414. JUGULAR VEINS.—Three veins in the neck are described under this name.

1. The external jugular (fig. 628) is the degenerated remnant of the most important of the fetal cervical veins, and is therefore variable. It originally drained the blood of the lateral and superior petrosal sinuses through the postglenoid foramen from the confluens lateralis, and the vestiges of this vessel persist as the mastoid vein. In the adult it arises by the junction of the occipital and posterior auricular vein over the hinder border of the sterno-mastoid, and lower down is joined by a large communicating vein from the temporo-maxillary (fig. 628, *), which emerges at the lower edge of the parotid gland, descends over the fascia across the sterno-mastoid from within and above, downwards and outwards.

This communicating stem is often so large that it appears as if it were the stem of the vein, and is often described as such, the true external jugular being then called posterior external jugular.

At the posterior border of the sterno-mastoid muscle, a short distance above the clavicle, this vessel turns inwards,

There is a pair of valves in this vein near, but not at, its termination, and usually a second pair as it is joined by the communicating vein, a third, usually rudimentary, pair is generally present a little below the ear.

2. **The common jugular vein** is the largest vein in the adult neck, to be seen hereafter (§ 449).

3. Close to the anterior median line the superficial cervical veins are very variable in their arrangement. A distinct **anterior jugular vein** (*vena mediana colli*) is only present in 62 per cent., and even then is often very small, except in cases where the external jugular vein is deficient. It may be

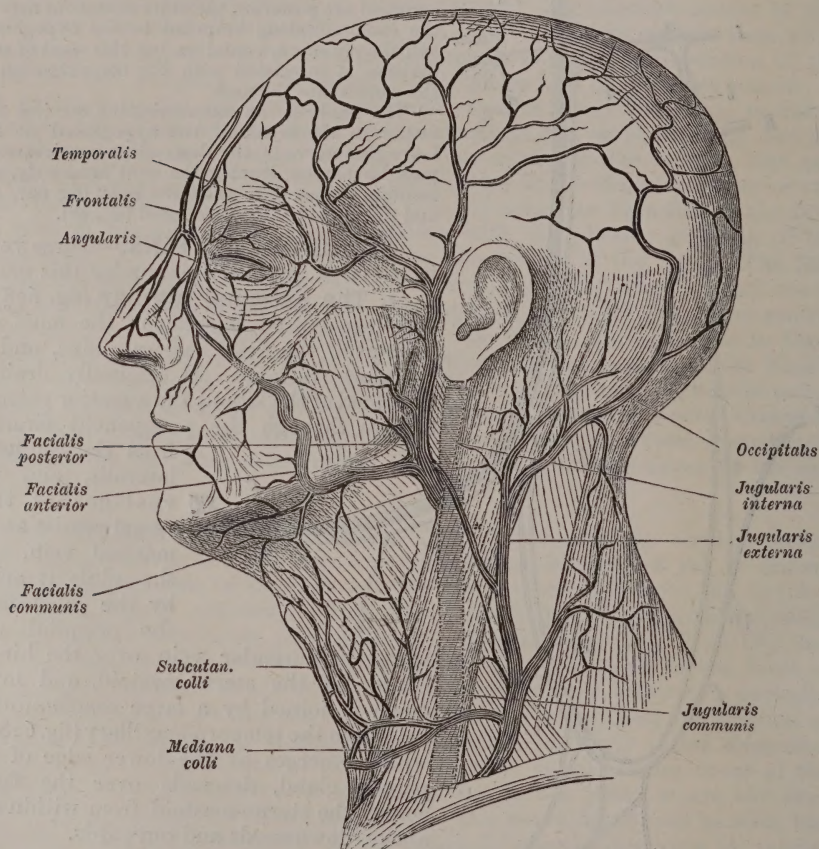


Fig. 628.—Superficial veins of the side of the head and neck.

double, or represented by a plexus, or single and unsymmetrical; a large anterior rarely co-exists with a large external jugular. When present it arises by the union of a submental with an infrahyoid vein, and descends internal to the sterno-mastoid to the lower third of the neck, at which point it turns outwards beneath, rarely over that muscle to end in the subclavian vein. This transverse stage of the anterior jugular is endangered in the operation of section of the sterno-mastoid for wry-neck. A transverse branch sometimes unites the two anterior jugulars below, but this vein seldom communicates with the underlying large network of thyroid veins. This vein is valveless.

Dissection.—Divide the sterno-mastoid in the middle and reflect it. Clean the sub-jacent infrahyoid group of muscles and the *digastric*. In exposing the *omo-hyoid*, the fascia which ties its posterior belly to the clavicle is to be left undivided, and the branches of nerves from the ansa infrahyoidea are to be followed to their distribution. The nerve to the posterior belly of the *omo-hyoid* underlies the intermediate tendon of that muscle.

415. OMO-HYOID (fig. 624) is a digastric muscle which underlies the *sterno-mastoid* and its sheath. Its posterior belly arises from a variable extent, usually about half of the superior margin of the scapula (fig. 220, *o.h.*), and sometimes from the suprascapular ligament. It passes forwards and slightly upwards beneath the *trapezius* and lies behind the clavicle, to which its lower border is bound by a firm fibrous expansion. It ends in a flat central tendon under the *sterno-mastoid* and over the sheath of the vessels, and from this the anterior belly ascends steeply, forming with the posterior portion an obtuse angle which is altered but little when the muscle is in action. It is inserted into the lower border of the body of the hyoid bone, external to and overlapping the *sterno-hyoid*. The *omo-hyoid* overlies the suprascapular nerve, brachial plexus, *scalene* muscles, phrenic nerve, the sheath of the cervical vessels, and the *sterno-thyroid* and *thyro-hyoid* muscles. The anterior belly is innervated by a branch of the descendens cervicis, the posterior by one from the ansa infrahyoidea (fig. 627), its nerve entering close to the central tendon.

The fibrous expansion which binds the tendon of the *omo-hyoid* to the clavicle is a portion of its own lower border expanded and blended with the overlying portion of the cervical fascia.

416. STERNO-HYOID (fig. 624) is a thin, flat band of parallel fibres arising from the hinder surface of the sternal end of the clavicle, and of the sterno-clavicular capsule, and from the contiguous surface of the presternum. From thence ascending and converging with its fellow, it is inserted into the lower border of the body of the hyoid bone by short tendinous fibres. It lies on the *sterno-thyroid* and *thyro-hyoid* muscles, and crosses the superior thyroid artery and the thyroid body.

In the median interspace between the two *sterno-hyoids*, the *thyro-hyoid* membrane, the *pomum Adami*, the *sterno-thyroid* muscles, the crico-thyroid space, and the cricoid cartilages appear.

The *omo-hyoid* and *sterno-hyoid* are separated parts of a deep cervical muscular sheet attached below to the shoulder-girdle (the cervical portion of the rectus-segment of the ventral muscle). The intermediate part below has degenerated into the fascia which ties the *omo-hyoid* to the clavicle, in which, not uncommonly, fleshy fibres are developed, forming additional heads for the *omo-hyoid*. The tendinous inscription is a trace of cervical metamerism, and not uncommonly traverses the *sterno-hyoid* at the same level, in which case the *sterno-hyoid* receives two filaments of nerves.

Dissection.—Divide the *sterno-hyoid* immediately above the clavicle and reflect it upwards, preserving its nerve. Clean the *sterno-thyroid* and *thyro-hyoid* muscles.

417. STERNO-THYROID (fig. 624), a ribbon of parallel fascicles, arises from the hinder surface of the presternum and the cartilage of the first rib, below and internal to the *sterno-hyoid*. It ascends, diverging a little from its fellow, to be inserted into the oblique line on the thyroid cartilage (fig. 629). It is covered by the *sterno-hyoid*, *omo-hyoid*, and *sterno-mastoid*, lies on the pretracheal fascia, the innominate vein, carotid artery, thyroid body, and its plexus of veins, trachea, and larynx. It may be crossed by a tendinous intersection. Its breadth varies directly with that of the thyroid body.

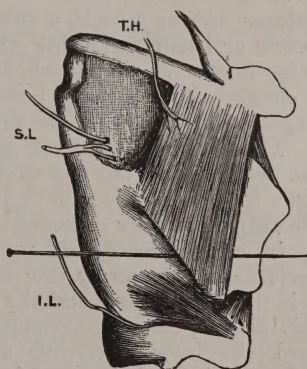


Fig. 629.—Thyro-hyoid muscle, a pin is passed through its origin which in this specimen was from a tendinous arch along the oblique line—I.L., external laryngeal nerve; S.L., superior laryngeal nerve and artery.

Thyro-hyoid (fig. 629) is a quadrate continuation of the *sterno-thyroid* upwards, and is variable in its degree of separation from that muscle. It arises from the oblique line on the thyroid ala (§ 499), and is inserted into the lower border of the body and great cornu of the hyoid bone. Being wider than the *sterno-hyoid* it usually projects to its outer side, beneath and even beyond the *omo-hyoid*.

The *omo-* and *sterno-hyoid* are depressors of the hyoid bone, the former is a tensor of the cervical fascia and can lift the fascial pressure from the jugular vein. All the four muscles act in bass vocalisation and forced inspiration. The *thyro-hyoid* elevates, and the *sterno-thyroid* depresses the thyroid cartilage. The nerve to the thyro-hyoid (figs. 627, *th*; 629, T.H) is derived from the ansa atlantis (§ 481), but descends along with the hypoglossal from which it appears to come off. The *sterno-thyroid* and *thyro-hyoid* are deeper delaminations of the same sheet as the preceding pair of muscles.

418. THE POSTERIOR INFERIOR TRIANGLE is the smallest of the four cervical spaces, and is bounded above by the *omo-hyoid*, below by the clavicle, and in front by the sterno-mastoid line (§ 410). It is covered in by the fascia joining the *omo-hyoid* to the clavicle, upon which lie the *platysma* and the supraclavicular cutaneous nerves (fig. 624), and through which the external jugular vein pierces. It contains the inferior cervical lymphatics, the subclavian, transverse and superficial cervical, and suprascapular arteries and veins, the *scalene* muscles, the phrenic nerve, and the brachial plexus. The subclavian vein is usually behind the clavicle, and, therefore, below the limit of the space. About fourteen small glands, on and under the *omo-hyoid*, receive the descending cervical lymphatics from the parts above, (fig. 622) and give off about six large efferent vessels, which unite on the inner edge of the *scalenus anticus* into a short **jugular lymphatic trunk**. On the right side this is about 6 mm. long, and ends in the right lymphatic duct. The left jugular lymphatic trunk is about 3 mm. long, and ends in the thoracic duct. These ducts both end below the level of the clavicle. A thin fascial expansion from the outer edge of the *scalenus anticus* separates the suprascapular vessels from the subclavian. There is often much loose, soft fat in this space.

419. THE SUBCLAVIAN ARTERY (fig. 630) lies deeply in this triangle wherein it forms an arch whose convexity is directed upwards, reaching to the level of the sixth cervical vertebra. It is divided into three stages by the *scalenus anticus* muscle, a first or **pectoral stage**, internal to this muscle; a second or **intermuscular stage** behind it; and a third or **cervical** from the outer border of the muscle to the lower border of the first rib, at which level it changes its name and becomes *axillary* (p. 269). Only the second and third stages lie in this space, the first being internal to it.

The **right subclavian artery** arises from the *arteria innominata* (§ 435), the left arises from the *arch* of the *aorta* (p. 346). These vessels, therefore, differ in their relations in their first stages. The **first stage of the right subclavian** lies under cover of the skin, *platysma*, fascia, the *sterno-mastoid*, *sterno-hyoid*, and *sterno-thyroid* muscles; it is crossed by the internal jugular and vertebral veins and by the vagus, superior cardiac, and phrenic nerves. Below it is the right pleura and the recurrent laryngeal nerve, and behind is the *longus colli* muscle, the transverse process of the first dorsal vertebra, the sympathetic cord, the inferior cardiac and recurrent laryngeal nerves. The subclavian vein, which lies below and in front, is separated from the artery by the phrenic nerve.

The **first stage of the left subclavian** (fig. 636, 9) is longer, a little smaller in calibre, and a little deeper than the right, and its commencement cannot be seen until the thorax is opened. In the thoracic part of its course it has the left pleura and lung in front, to the left, and, for a little, posterior to it. It is covered, in addition, by the presternum, first rib, and sterno-clavicular joint, by its own vein (which crosses it at the outlet of the thorax, and joins the

jugular vein, forming the vena innominata in front of the artery—fig. 638), and by the phrenic nerve. The trachea, œsophagus, left recurrent laryngeal nerve, and thoracic duct lie behind and internal to it. The left carotid is anterior and to its inner side, and the vagus is parallel, anterior, and internal.

In the neck the relations of the left resemble those of the right. The *sterno-mastoid*, *sterno-hyoid*, and *sterno-thyroid* muscles, the vagus, phrenic and sometimes the superior cardiac nerves overlie it, and the *longus colli*, spine, and sympathetic are behind it.

This stage of the artery in the embryo lies at the anterior part of the wall of the celom.

In the **second stage** the relations are nearly the same on both sides. The subclavian artery passes transversely outwards, under cover of the *scalenus*

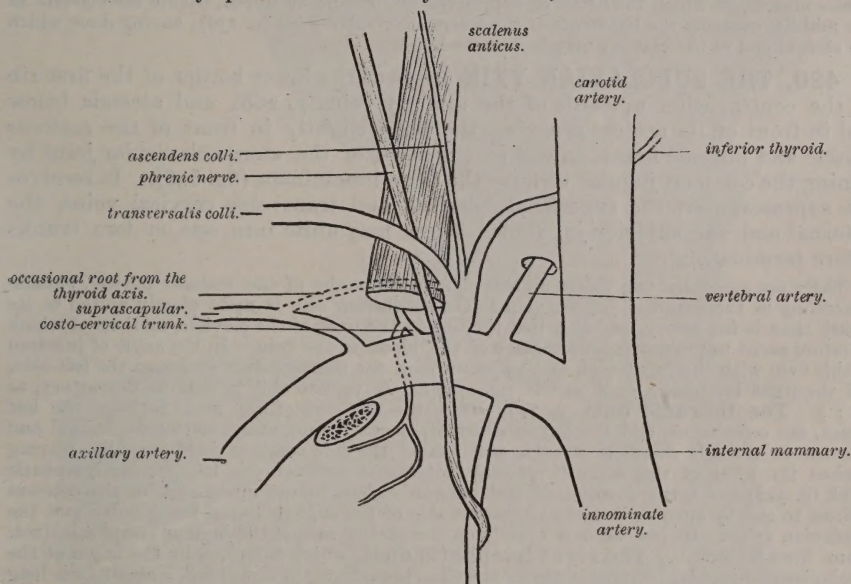


Fig. 630.—Scheme of the subclavian artery. The scalenus anticus is represented as cut above it and the first rib below it.

anticus and phrenic nerve, and upon the *scalenus medius*. The pleura and dome-like fascia lie below (fig. 423), and part of the brachial plexus lies above it. In this stage the artery has reached its highest point.

In the **third**, longest and most exposed stage (fig. 631, 2) the artery runs downwards and outwards, and is only covered by skin, platysma, cervical fascia, the fascial expansion from the *omo-hyoid* to the clavicle, and the weaker subjacent fascial expansion from the *scalenus anticus*. It is crossed by the supraclavicular nerves which lie over the cervical fascia, by the end of the external jugular, the transverse cervical, and suprascapular veins; sometimes the nerve to the *subclavius* muscle also crosses it. The clavicle and *subclavius* muscle and the suprascapular artery lie over it in the ordinary position of the arm, but by depression of the shoulder they can be placed in front of the axillary artery. In this stage the artery lies on the first rib, having the *brachial plexus* and *omo-hyoid* muscle obliquely above it and the *scalenus medius* behind it. Its vein lies below and on a plane anterior to it.

In this stage the artery is most easily ligatured, being reached by dividing the skin and fascia along the upper edge of the clavicle, between the *sterno-mastoid* and the *trapezius*, when, on drawing the overlapping veins aside, the artery appears as it emerges from beneath the *scalenus anticus*. The scalene tubercle on the first rib, which can be felt at the bottom

of the incision by the finger, is an important guide. The second stage has been exposed and ligatured several times by dividing the *scalenus anticus*. The first stage of the left subclavian has been once tied unsuccessfully, that on the right has been tied at least sixteen times, but with unsatisfactory results.

The subclavian artery can be compressed on the first rib. In most persons, by depressing and pushing back the clavicle, the artery can be pinched between the two bones, a trick well known by malingerers as a means of weakening or obliterating the pulse. Morphologically each stage of the subclavian artery has a different nature. The first stage of the right is the modified root of the fourth aortic arch; the end of the first stage on the right and the whole of the first on the left are, like the second stages on both sides, the intercostal arteries of the space between the seventh cervical and first dorsal segment. The third stage is the modified lateral branch of this intercostal trunk.

Dissection.—If the dissector of the upper limb has finished his examination of the *subclavius* muscle, to which the nerve of supply (p. 273) should be traced, divide the clavicle in the middle, examine the ligaments of the sterno-clavicular joint (p. 139); having done which the sternal end of the clavicle may be removed.

420. THE SUBCLAVIAN VEIN arises at the lower border of the first rib as the continuation upwards of the axillary vein (p. 268), and ascends below and in front of its artery, grooving the bone slightly in front of the *scalenus* muscle and phrenic nerve, to end at the back of the sterno-clavicular joint by joining the common jugular to form the vena innominata (fig. 638). It receives the suprascapular, the superficial cervical, and transverse cervical veins, the external and the anterior jugulars. These may unite into one or two trunks before terminating.

There are generally two valves in this vein at the border of the *scalenus* muscle, outside the ending of the external jugular vein. The subclavian vein is more closely united to its sheath than is the artery, and it is tied thereby to the back of the clavicle, motions of which therefore assist in promoting the passage of the blood in the vein. In the angle of junction of this vein with the jugular on the upper surface, the thoracic duct enters on the left side, and the right lymphatic duct on the right side. In calibre this vein is to the artery, as 4·7 : 3. **The thoracic duct** (p. 349) enters the left side of the neck between the left pleura, the oesophagus, and the left subclavian artery; it then passes outwards, behind and external to the left common carotid, and behind the left common jugular vein. Having reached the level of the seventh cervical vertebra it receives the left jugular lymphatic trunk (p. 548) and turns downwards and outwards close to the inner edge of the *scalenus anticus*, to end by opening into the re-entrant side of the angle between the jugular and the subclavian veins. Its last valve is usually on the cardiac side of the jugular lymphatic duct, 7 mm. from its mouth. **The right lymphatic duct**, which is formed by the union of the subclavian and jugular lymphatic trunks as well as those from the right lung, is about 1 cm. long and 2 mm. in diameter, and passes downwards and inwards to open into the angle between the right subclavian and right jugular veins. It has usually a double valve at its termination.

421. BRANCHES OF THE SUBCLAVIAN ARTERY.—The subclavian artery gives off in its first stage (1) the vertebral; (2) internal mammary; (3) inferior thyroid; (4) ascending cervical; (5) transverse cervical; (6) superficial cervical; and (7) suprascapular arteries. The last five usually arise together, but their mode of origin is variable. All may arise by one common stem, which is then called the **thyroid axis**; but the irregularities of origin are so frequent that it is better to consider them as separate vessels which are liable to different degrees of fusion at their origins. In the second stage two branches arise, cervicalis profunda and superior intercostal, usually by a common **costo-cervical axis**.

422. THE VERTEBRAL ARTERY (fig. 630), which can be seen at present only partially, arises from the posterior and upper surface of the subclavian. Its course may be divided into four stages—cervical, vertebral, atlantic, and intracranial. In the first it ascends a little outwards behind the common jugular vein, is crossed by the inferior thyroid artery (and by the thoracic duct on the left), and lies in the interval between the *scalenus anticus* externally and the *longus colli* internally, until it enters the transverse foramen of the sixth cervical vertebra. Behind it lie the sympathetic cord and the costal process of the seventh cervical (fig. 631, +).

In its second stage, which can be exposed by dissecting away the cervical intercostal muscles (p. 314), it ascends in the transverse processes of the

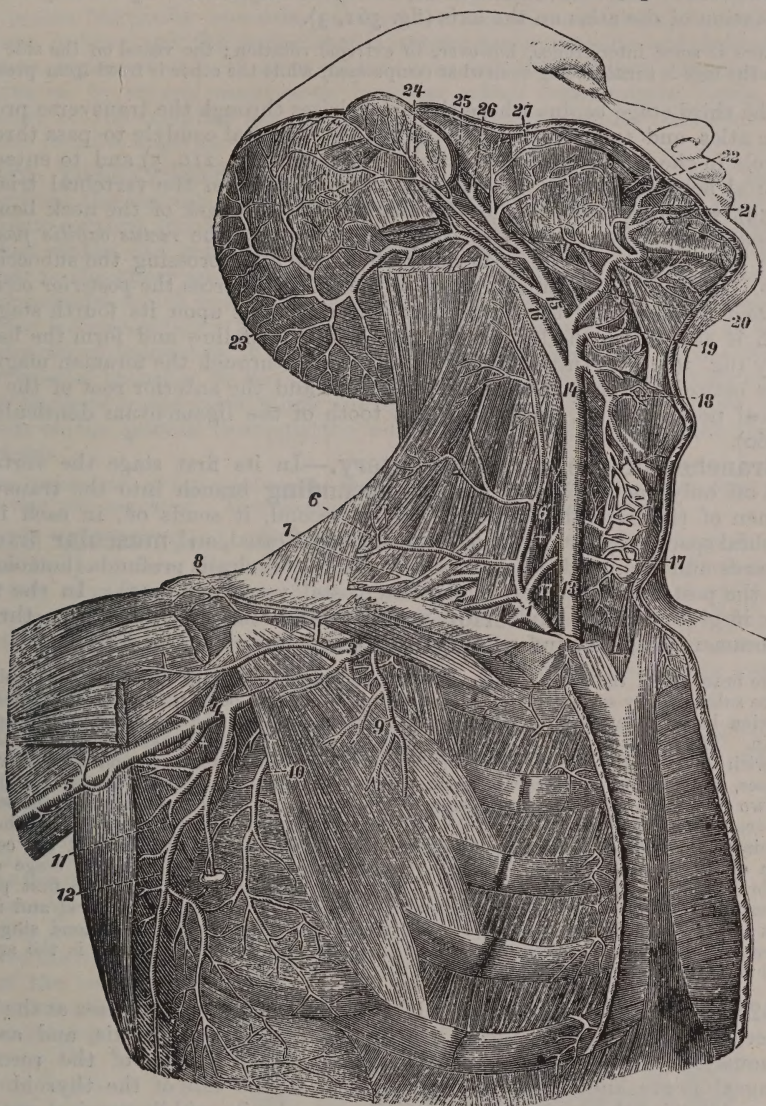


Fig. 631.—Branches of the arteries of the head and neck—1, first stage of right subclavian artery; 2, third stage; 3, first stage of axillary artery; 4, third stage; 5, brachial; 6, superficial cervical artery; 7, posterior scapular; 8, acromial axis and rete; 9, pectoral branch of the thoraco-acromial artery; 10, long thoracic; 11, dorsalis scapulæ; 12, subscapular; 13, common carotid; 14, bifurcation; 15, external carotid; 16, internal carotid; 17, inferior thyroid; 18, superior thyroid; 19, lingual; 20, facial; 21, inferior labial; 22, superior coronary; 23, occipital; 24, posterior auricular; 25, temporal; 26, internal maxillary; 27, transverse facial. The scalenus anticus crosses the artery between 1 and 2.

neck vertebræ (fig. 621) to the atlas, surrounded by a plexiform arrangement of veins and a finer network of sympathetic nerves from the inferior cervical

ganglion, and it lies in front of the spinal nerves. In the upper part of this canal it is loose and curved outwards, so that it may not be injuriously affected by rotation of the atlas on the axis (fig. 361, 3).

There is some interference, however, in extreme rotation; the vessel on the side from which the face is turned being somewhat compressed, while the other is freed from pressure.

The third stage begins where the artery rises through the transverse process of the atlas, and turns backwards around the occipital condyle to pass through the hole in the posterior occipito-atlantic ligament (fig. 210, 5) and to enter the subdural space. In this stage it lies at the bottom of the vertebral triangle (p. 259), which has been seen in the dissection of the back of the neck beneath the *complexus*, between the two *oblique* muscles and the *rectus capitis posterior major*, and it rests on the posterior arch of the atlas crossing the suboccipital nerve. Behind the articular process of the atlas it pierces the *posterior occipito-atlantoid ligament* and the *dura mater*, entering thus upon its fourth stage, in which it ascends on the basilar process to join its fellow and form the basilar artery (fig. 361, 4). Intracranially, as it ascends through the foramen magnum, it lies between the hypoglossal nerve in front and the anterior root of the first cervical nerve behind, under the first tooth of the ligamentum denticulatum (p. 260).

Branches of the vertebral artery.—In its first stage the vertebral gives off only one small and variable **ascending** branch into the transverse foramen of the seventh vertebra. In its second, it sends off, in each inter-vertebral space, a **lateral spinal** into the spinal canal, and **muscular** branches outwards and backwards to anastomose with the *cervicalis profunda* (homologous with the posterior branches of the intercostal vessels, p. 347). In the third stage it gives off two **posterior meningeal** branches, which pass through the foramen magnum, and a **communicating** branch to the occipital.

The branches of the fourth stage, anterior and posterior spinal and posterior cerebellar, will be subsequently seen (§ 538). The vertebral artery has been tied in several cases; the operation being practically the same as that for the ligation of the first stage of the subclavian. The plexus of veins which surrounds the artery in the vertebral canal (in accordance with the law of Rüdinger, that arteries in bony canals are surrounded with venous plexuses, for obvious mechanical reasons) unites at the sixth cervical transverse process into two channels, one of which escapes with the artery, the other passes through the seventh costo-transverse foramen. These unite and pass forwards and downwards to join the *vena innominata* on each side close to its origin. By these channels the blood of the cervical region of the cord is returned, but not that of the branches of the fourth stage of the vertebral artery, which is poured into the system of meningeal sinuses. The first part of the vertebral artery is a precostal anastomosis (fig. 150), the union of the first and second stages is the root of the sixth dorsal artery, the trunk artery in the second stage is a retrocostal anastomosis; its third stage is its neural branch and its fourth is the anterior spinal vertical anastomosis.

423. THE INFERIOR THYROID ARTERY (fig. 631, 17) arises at the inner border of the *scalenus anticus*, usually from the thyroid axis, and ascends tortuously inwards in front of the vertebral artery and of the recurrent laryngeal nerve and the *longus colli* muscle to the side of the thyroid body. It is crossed by the cord of the sympathetic, or by its middle cervical ganglion, and lies behind the sheath of the carotid vessels. Its branches are **pharyngeal**, **oesophageal**, and **tracheal**, which supply the parts indicated by their names; **thymic**, which descends into the anterior mediastinum and supplies the thymus, and some lymphatic glands as well; **inferior laryngeal**, which accompanies the recurrent laryngeal nerve; and **terminal**, which subdivide in the thyroid body.

This artery is sometimes tied in case of bronchocele, the operation being similar to that for the ligation for the common carotid. The inferior thyroid veins which do not correspond to the arteries will be described later in connection with the thyroid body (§ 506).

424. ASCENDING CERVICAL, (fig. 631, 6') a small vessel which arises in common either with the inferior thyroid or with the transverse cervical artery and passes vertically upwards, internal to the phrenic nerve, between the *scalenus anticus* and the *rectus capitis anticus major*, outside and behind the common jugular vein. It gives off *muscular* and *intervertebral* branches, and terminates by several *anastomotic* branches which communicate above with branches of the occipital and ascending pharyngeal arteries. Its two *venæ comites* join the superior transverse cervical vein (§ 425).

425. TRANSVERSE CERVICAL or *posterior scapular* (fig. 632) usually arises from the thyroid axis, or in common with the next, or more rarely from the costo-cervical trunk, and passes outwards over the *scalene* muscles and the brachial plexus, and beneath the *omo-hyoid*, the *trapezius*, and the *levator anguli scapulae* to the upper angle of the scapula. Here it turns downwards between the *rhomboidei*, which overlie it, and the *serratus magnus* and *serratus posticus superior*, which are below it, and having given off *muscular* branches to all the muscles which it touches, it terminates below in the *latissimus dorsi*. Besides these smaller branches to the surrounding parts, it gives off two larger vessels, a *supraspinous* to the parts filling the supraspinous fossa, and a *cervical*, which ascends on the *splenius* to supply the muscles of the back of the neck over the *complexus*.

The transverse cervical veins empty their blood into the external jugular close to the subclavian vein in general. They possess a few small often imperfect valves.

426. SUPERFICIAL CERVICAL (fig. 631, 6) is very often a branch of the last or else may arise separately from the third stage of the subclavian; it is an artery of variable size, which coats along the outer margin of the trapezius, supplying *glandular* and *muscular* branches to the neighbouring lymphatic glands and muscles, and ending in a *communicating* branch which anastomoses with the descending branch of the occipital. The two *venæ comites* join the foregoing veins.

427. SUPRASCAPULAR (figs. 630, 632) arises either from the thyroid axis or independently from the subclavian. It passes outwards behind the clavicle, lying on the *scalenus anticus*, separated from the subclavian artery, which it crosses, by the fascia attaching the *omo-hyoid* to the clavicle, and, having reached the upper margin of the scapula, it crosses over the suprascapular ligament and pierces the supraspinous fascia to dip into the outer part of the supraspinous fossa beneath the muscle which fills it. The artery passes beneath the spino-glenoid ligament in the great scapular notch, and terminates in the infraspinous fossa. Its branches are *muscular*, to the *scalenus anticus* and *subclavius* muscles; *nutrient*, to the clavicle; *acromial*, to the rete acromiale (fig. 631, 8); *subscapular*, which dips into the

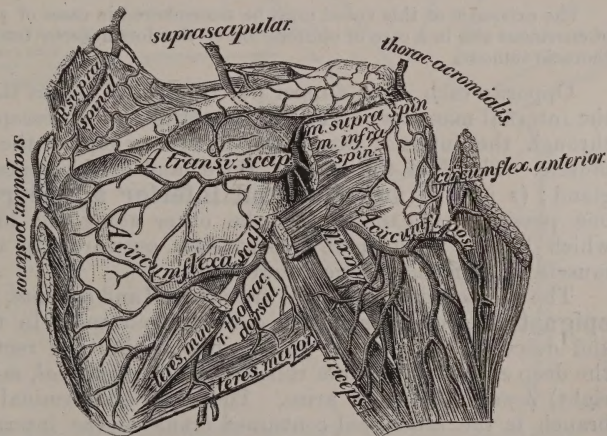


Fig. 632.—Scapular anastomosis.

subscapular fossa before the artery crosses the ligament of the notch (fig. 373; p. 270); *supraspinous*, to the muscle of that name; *articular*, to the shoulder-joint; *suprascapular nutrient*, to the scapula above the spine; and *infraspinous*, which anastomoses in the infraspinatus muscle with the dorsalis scapulæ. This artery is accompanied by two veins whereof the superior is the larger; they usually unite into one trunk in the inferior cervical triangle and end by joining the subclavian, either with or beside the external jugular. These veins have several well-marked valves.

428. THE INTERNAL MAMMARY ARTERY arises from the lower border of the subclavian at the inner edge of the *scalenus anticus* (fig. 630), and descends inwards behind the clavicle and first rib, entering the thorax where it has been already followed. It passes (figs. 421, 9; 423) external to the margin of the sternum and is covered by the costal cartilages and internal *intercostal* muscles, lying on the *triangularis sterni*, which separates it from the subjacent pleura, and finally dividing in the sixth intercostal space into its terminal branches. In the neck it is covered by the common jugular and the subclavian veins and is crossed by the phrenic nerve, which passes from without inwards over the artery to descend behind and on its inner side. The internal mammary veins are two, one on each side of the artery, but generally of unequal size and with many valves. They unite into one channel behind the first intercostal muscle, and end on the inner side of their artery by opening into the vena innominata. That of the right side often opens into the superior vena cava.

The branches of the internal mammary are all intrathoracic, the first or **comes nervi phrenici**, arises where the phrenic nerve crosses the artery, and is carried downwards with the nerve to the pleura and pericardium. **Anterior mediastinal** branches pass inwards to the lymphatics of that space and form a close parietal plexus in it, **thymic** branches supply the remains of the thymus gland, **pericardiac** pass to the anterior surface of that membrane, and **sternal** branches nourish the breast bone. Close to the first rib it gives off a **lateral infracostal** branch (fig. 421, 12), which is very variable in size, and which, when large, descends on the inside of the ribs, external to their cartilages, and anastomoses with the upper intercostal arteries.

The existence of this vessel must be remembered in cases of paracentesis. I have seen it of enormous size in a case of obliteration of the dorsal aorta from the pressure of an intrathoracic tumour.

Opposite each of the upper five intercostal spaces three branches arise from the internal mammary—(1) **perforating**, which escapes close to the sternum through the internal intercostal muscle to supply the parts over the pectoral muscle. Those of the second, third, and fourth spaces supply the mammary gland; (2 and 3) **superior and inferior anterior intercostal** branches, one passing along the upper, the other along the lower border of the rib which bounds each space; these pass outwards in the internal intercostal muscle to join the aortic intercostals.

The two terminal branches are *internal* and *external*, the former or **superior epigastric** goes through the costo-xiphoid space in the diaphragm (p. 465), and descends close to the middle line behind the rectus, to anastomose with the deep epigastric. From this, *muscular*, *peritoneal*, *metasternal*, and (from the right) *hepatic* branches arise. The external terminal or **musculo-phrenic** branch is the functional continued trunk of the internal mammary, and runs in the costal attachment of the diaphragm, giving off a very irregular series of anterior intercostal branches in the lower intercostal spaces, ending by anastomosing with the ascending branches of the circumflex iliac artery.

The internal mammary artery has been tied, but it is an operation rarely required, and, in method, is practically identical with ligature of the first stage of the subclavian artery.

429. THE COSTO-CERVICAL trunk (fig. 630) is usually small and very deep, arising behind or external to the *scalenus anticus*. It divides at once into two branches.

Cervicalis profunda, morphologically the posterior intercostal artery for the seventh cervical space, which dips backwards between the seventh and eighth cervical nerves, and then passes between the costal process of the seventh cervical vertebra and the neck of the first rib. It then ascends posteriorly on the *semi-spinalis colli* beneath the *complexus*, in the groove between the cervical spines and the transverse processes as far as the axis. Its branches are *muscular* to the adjacent muscles, *vertebral* to the spinal canal through the intertransverse spaces, and *descending*, which anastomose with the transverse cervical and princeps cervicis.

The venæ comites unite close to the seventh cervical transverse process into one trunk which usually joins the vertebral vein close to its termination.

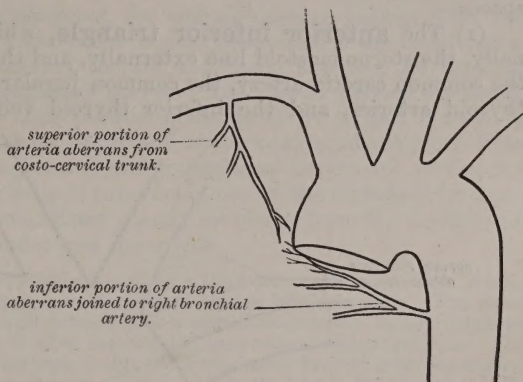


Fig. 633.—Scheme of common arrangement of the arteria aberrans.

Superior intercostal arises with the last, on the right behind the *scalenus anticus*, on the left often on the inner side of that muscle. It crosses the neck of the first rib and enters the thorax external to the first dorsal nerve. It sends outwards the intercostal branch in the first (left) intercostal space, or in the first and second (right). These correspond in relation to the aortic intercostals of the spaces below them (p. 347) and send off retrocostal anastomotic branches.

The superior intercostal veins have been already described along with the vena azygos (p. 349).

root portion which becomes part of first stage of normal subclavian.

obliterated part whose trace remains as arteria aberrans.

430. ARTERIA ABERRANS.

—The right subclavian, or its costo-cervical branch, usually sends off, internal to the superior intercostal, a fine descending branch, which enters the thorax and passes backwards and inwards behind the oesophagus (fig. 633).

In most cases it cannot be traced farther than the front of the third dorsal vertebra, but in about 25 per cent. it may be followed, in a well-injected body, across the spine to join the thoracic aorta below the ductus arteriosus. This is the remains of the right fourth aortic arch (p. 85), and in those cases wherein the root of the right subclavian has become obliterated this channel remains dilated and constitutes the source of blood supply to the

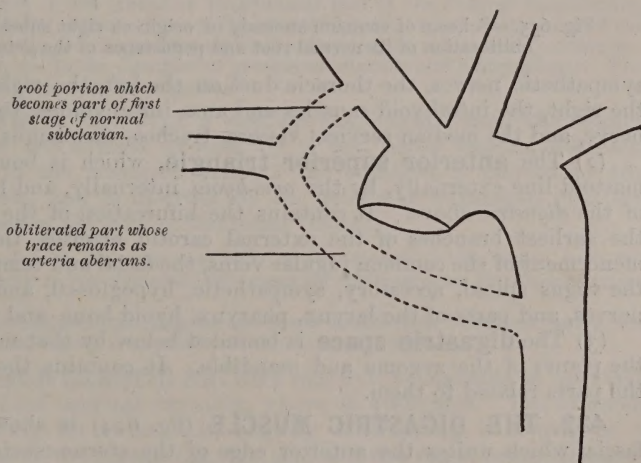


Fig. 634.—Scheme of fourth right aortic arch before its atrophy.

right upper limb (fig. 635). In such cases the right subclavian appears to arise leftmost from the aortic arch and to pass behind the œsophagus. Correlated with this is generally a direct, not recurrent, course of the right inferior laryngeal nerve and a dextral termination of the thoracic duct.

431. THE CAROTID TRIANGLE.—The *great anterior triangle* of the neck, on each side, is subdivided by the *omo-hyoid* and *digastric* muscles into three spaces—

(1) The **anterior inferior triangle**, which has the median line internally, the sterno-mastoid line externally, and the *omo-hyoid* above. It contains the common carotid artery, the common jugular vein, the vertebral and inferior thyroid arteries, and the inferior thyroid veins; the vagus, recurrent, and

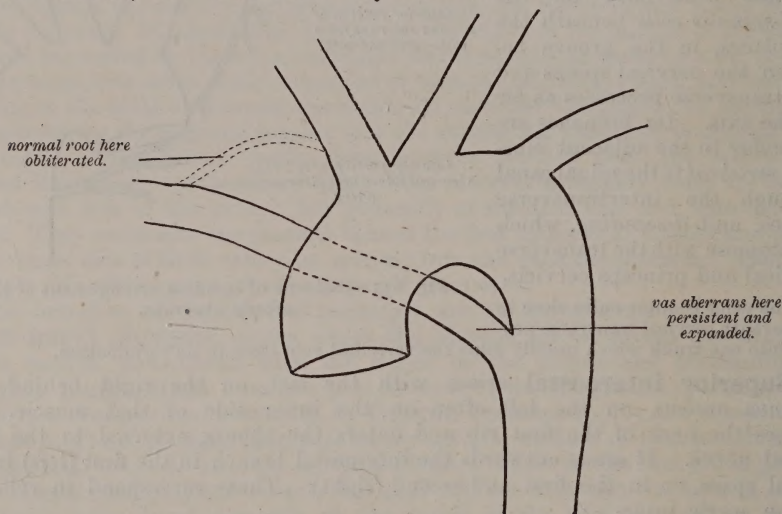


Fig. 635.—Scheme of common anomaly of origin of right subclavian artery by the obliteration of its normal root and persistence of the arteria aberrans.

sympathetic nerves, the thoracic duct on the left, the right lymphatic duct on the right, the infrahyoid muscles and ansa infrahyoidea, the external laryngeal nerve, and the median cervical viscera, trachea, œsophagus, and thyroid body.

(2) The **anterior superior triangle**, which is bounded by the sterno-mastoid line externally, by the *omo-hyoid* internally, and by the posterior belly of the *digastric* above. It contains the bifurcation of the common carotid and the earliest branches of the external carotid arteries, the internal and commencement of the common jugular veins, the facial and temporo-maxillary veins; the vagus spinal, accessory, sympathetic, hypoglossal, and descending cervical nerves, and parts of the larynx, pharynx, hyoid bone, and lymphatic glands.

(3) The **digastric space** is bounded below by that muscle, and above by the planes of the zygoma and mandible. It contains the salivary glands and the parts related to them.

432. THE DIGASTRIC MUSCLE (fig. 624) is shown when the strong fascia, which unites the anterior edge of the sterno-mastoid to the mandible, is divided, and when the root of the communicating branch from the temporo-maxillary vein to the external jugular is reflected. The margin of the parotid gland, which usually overlaps it a little, should also be rendered definite, and the cervical branches of the facial nerve cleaned and preserved (fig. 614).

The digastric arises from the mastoid edge of the digastric groove in the temporal bone (fig. 320) by short tendinous fibres. These become fleshy and

form a flattened fusiform *posterior belly*, which descends forwards to end in a tendon above the great cornu of the hyoid bone, to which it is tied by a strong fibrous expansion. Opposite the lesser cornu of the hyoid this gives origin to the fleshy fibres of the *anterior belly*, which ascend to be inserted into the *digastric impression* on the mandible (fig. 663).

The posterior belly is at first covered by the *sterno-mastoid* and *splenius* muscles, then by cervical fascia, *platysma*, the communicating jugular vein, the superior cervical glands (fig. 622), and inframaxillary branches of the facial nerve. It lies upon the external and internal carotid and facial arteries, the internal jugular vein, the vagus and hypoglossal nerves. Its tendon pierces the fleshy belly of the *stylo-hyoid* muscle. The parotid gland is above it, and it receives its nerve from the facial (§ 456) at its upper and inner margin, about 3 cm. from its origin (fig. 655). The occipital artery and hypoglossal nerves are overlapped by its lower edge. The anterior belly is superficial, lies on the *mylo-hyoid* muscle, internal and anterior to the submaxillary gland; its nerve, from the mylo-hyoid branch of the fifth, enters its hinder and inner side.

The fibres of the anterior belly are supplemented by a large contingent of fascicles arising from the body of the hyoid bone, internal to the central tendon of the muscle. The inner margin of the anterior belly is never well defined, as it is united to its fellow by an expansion, originally of fleshy fibres, but which is often degenerated into a mere connective web. The attachment of the tendon to the hyoid bone is due to an expansion derived from the tendon itself. The hinder belly is the longer, as 7 : 5. In the undisturbed neck, the posterior belly forms an angle of 45° with the horizon, the anterior belly one of 15°. In action the included angle of 120° between the bellies increases to 130°.

The action of the digastric depends on the relative degree of fixity of its three points of attachment,—with a fixed skull and jaw it raises the hyoid, as in deglutition; with a fixed hyoid and skull it depresses the jaw; with a fixed hyoid and mandible, as when the chin is placed on the table, it can draw the skull backwards. The two bellies always act together.

The two digastric muscles of the neck, *omo-hyoid* and *digastric*, afford some interesting points of comparison; in both, the digastric condition depends on metamerism, but in the former, the two parts derived from contiguous metameres are comparable portions of the ventral musculature, the hinder belly being displaced outwards on account of its attachment to the shoulder girdle. In the latter, the two united portions are heteronomous—the anterior belly being a part of the central or longitudinal part of the ventral musculature, the posterior being a modified portion of one of the branchial bar muscles. Anomalies of the *omo-hyoid* are, consequently, for the most part in the direction of a return to continuity; anomalies of the *digastric* are in the direction of greater subdivision and independence. The innervation of the bellies in each case is significant.

433. STYLO-HYOID (fig. 675), a slender band, arises from the hinder and outer surface of the styloid process by a flat, short tendon, descends above and internal to the posterior belly of the *digastric*, is pierced by the tendon of that muscle, and is inserted by an indefinite expansion into the body of the hyoid bone at the root of the lesser cornu.

It is a slip segmented from the posterior belly of the *digastric*. Its nerve, from the facial, arises with the nerve to the *digastric*, but passes forwards to enter the hinder surface of the muscle.

Dissection.—By dividing and reflecting the *omo-hyoid* muscle from its central tendon, the sheath of the great cervical vessels is exposed and should now be opened.

434. THE COMMON CAROTID ARTERY (fig. 631, 13) ascends on each side to the level of the third cervical vertebra, where it bifurcates. The common jugular vein lies along its outer side, slightly overlapping it above, in a separate compartment of the sheath (fig. 621, j.); and the vagus nerve descends in a canal in the hinder part of the septum between these vessels, but lies nearer to the vein than to the artery. The two carotid arteries are only 2 cm. apart on the level of the top of the sternum, but are 6 cm. asunder at their bifurcation, the plane of which is also behind that of their origin, especially in the male adult neck.

The cervical relations of the two carotids are similar, but they differ in

origin, as the right arises from the innominate trunk (§ 435), and has consequently no thoracic stage, while the left arises from the arch of the aorta directly within the thorax (p. 347).

The thoracic portion of the left carotid (fig. 636, 8) is about 4 cm.

long, and lies behind the presternum and sterno-clavicular joint and the origins of the *sterno-hyoid* and *thyroid* muscles. It is crossed by the commencement of the left vena innominata and by the remains of the thymus gland. The arteria innominata and inferior thyroid veins lie to its right, the left pleura and lung, the jugular vein and vagus, lie to its left side, while the left subclavian is behind and to the left. It lies on the trachea, cesophagus, and thoracic duct.

In the neck the right carotid is the larger in calibre, a little more superficial, and not so much overlapped by its vein below; the left usually bifurcates at a little lower level.

435. THE ARTERIA INNO-MINATA (fig. 636, 7) on the right side corresponds generally in its relations to the thoracic stage of the left carotid; it arises opposite the fourth dorsal vertebra from the beginning of the aortic arch and behind the pre-mesosternal articulation; it is about 4 cm. long, and ends opposite the right sterno-clavicular articulation by dividing into the right carotid and right subclavian arteries. It lies on the trachea, behind the sternum, right sterno-clavicular joint, *sterno-hyoid* and *thyroid* muscles, and the remains of the thymus. It is crossed by the left vena innominata, which is tied to it by a lax fascial sheath (**Cooper's fascia**); to its right side descends the right vena innominata and the vagus, to its left the inferior thyroid veins and the left carotid.

The relation of the triangle between the two innominate veins and the artery (**Mott's space**) is of surgical importance, as the artery has been in seventeen cases tied. The arteria innominata is part of the modified fourth right aortic arch.

436. Each CAROTID ARTERY

in the anterior inferior triangle is covered by skin, *platysma*, fascia, by the *sterno-mastoid*, *sterno-hyoid* and *sterno-thyroid* muscles, and by its sheath; is crossed by the anterior jugular vein, by branches of the *ansa cervicalis*, and is overlapped by the thyroid body.

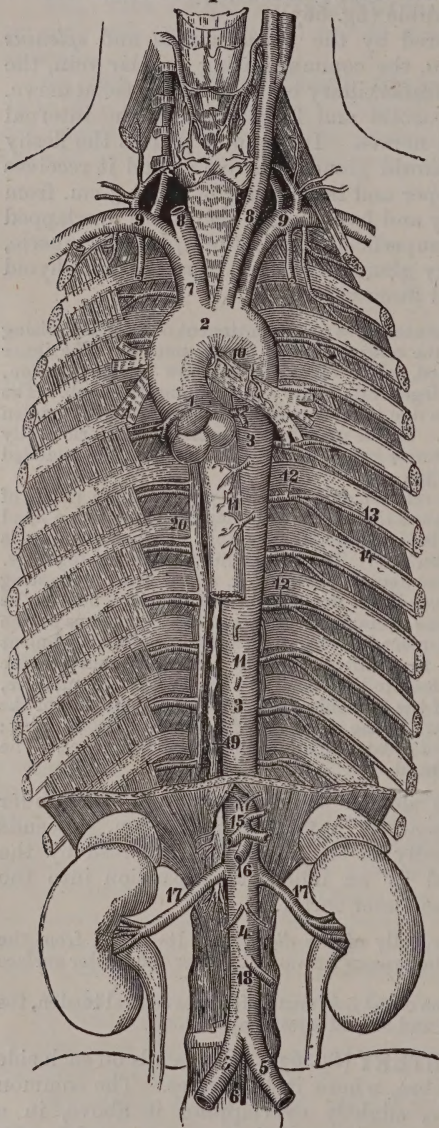


Fig. 636.—Course and branches of the aorta—7, arteria innominata; 8, left carotid; 9, left subclavian, with the vertebral arising from it immediately above the figure.

Internally it is related below to the trachea, œsophagus, and thyroid body, and above to the larynx and pharynx; externally to its accompanying jugular vein and vagus nerve, and it lies upon the back wall of its sheath, the inferior thyroid artery (which separates it from the vertebral artery), and also on the vertebral column, *longus colli* muscle, sympathetic and recurrent laryngeal nerves.

In the *anterior superior triangle*, having passed behind the *omo-hyoid*, it is only covered by skin, *platysma*, fascia, and overlapped by the edge of the *sterno-mastoid*, and is crossed by the *descendens cervicis* nerve, the *sterno-mastoid* branch of the superior thyroid artery, and the superior thyroid vein. In this stage it is easily found for deligation, and can be felt pulsating. Its lateral relations are the same as in the lower stage, and it lies on its sheath, which separates it from the spine, *longus colli*, and sympathetic nerve.

The common carotid gives off no lateral branches, with the exception of minute *vasa vasorum*, and so does not alter in sectional area, although it alters in sectional shape, being elliptical with sagittal long axis below, elliptical with coronal long axis above, and circular in the middle. Two lymphatic glands overlie the bifurcation of the artery, receiving their lymph from the submaxillary and alveolar lymphatics. According to Chassaignac, the artery may be compressed against the prominent costal process (carotid tubercle) of the sixth cervical vertebra.

Opposite the thyroid cartilage, or about 2 cm. below the angle of the jaw, the common carotid divides into its two branches, the external and internal carotids.

The external carotid is the modified third aortic arch, and supplies the oral and post-oral visceral arches and the side wall of the head, including the skull and dura mater. In the adult its diameter is to that of the internal as 6 : 7 at its origin, but in the infant at birth it was as 5 : 8.

437. THE EXTERNAL CAROTID arises on the internal side of the internal carotid (fig. 631, 15) about 2 cm. below the angle of the jaw, in the *anterior superior triangle*, but passes beneath the *digastric* muscle into the digastric space, and ends above by turning inwards behind the middle of the ramus of the mandible, from which point its continuation is named the **internal maxillary artery**. It is about 5 cm. long, sinuously curved, and diminishes as it ascends. It is covered by skin, *platysma*, cervical fascia, and superior cervical lymphatic glands, is overlapped at its origin by the edge of the *sterno-mastoid*, is crossed by the *inframaxillary* branches of the facial nerve, the *temporo-maxillary*, *lingual*, and *facial* veins; and it sinks under the *digastric* and *stylo-hyoid* muscles and the *hypoglossal* nerve to enter the *parotid gland* on a level deeper than the *facial* nerve and *temporo-maxillary* vein. It lies upon the *superior laryngeal* nerve, which separates it from the *prevertebral* muscles, and on the *stylo-glossus* and *stylo-pharyngeus* muscles, the *styloid process*, or when that is short, on the *stylo-hyoid ligament*, on the *glosso-pharyngeal* nerve, and a portion of the *parotid gland*. All these parts, except the first, separate it from the internal carotid.

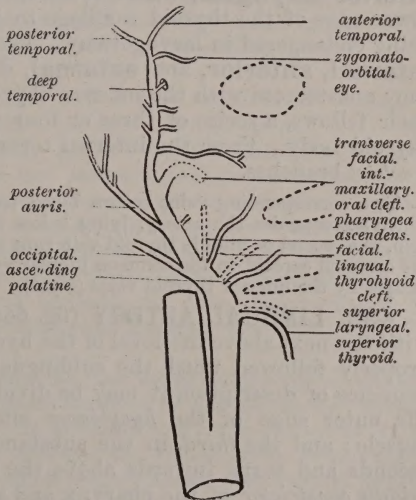


Fig. 637.—Diagram of the branches of the external carotid artery. Deep branches marked as dotted lines.

External to it is the internal carotid, internally it is related to the great cornu of the hyoid bone, the side of the pharynx, submaxillary gland, tonsil, and a portion of the parotid.

The branches of the external carotid are usually eleven, but some of these may arise by common stems in different modes of grouping. They may be classed as follows:—

1. To the visceral tube below the hyoid arch = superior thyroid.
2. To the lower border of the oral cleft and mandibular arch $\left\{ \begin{array}{l} \text{internally} = \text{lingual.} \\ \text{externally} = \text{facial.} \end{array} \right.$
3. To the upper border of the oral cleft and palato-pharyngeal region $\left\{ \begin{array}{l} \text{internally} = \text{ascending pharyngeal.} \\ \text{externally} = \text{ascending palatine.} \end{array} \right.$
4. To the parts derived from the maxillary lobe $\left\{ \begin{array}{l} \text{externally} = \text{transverse facial.} \\ \text{internally} = \text{internal maxillary.} \end{array} \right.$
5. Posterior branches, sterno-mastoid, occipital, posterior auricular, and temporal.

438. SUPERIOR THYROID ARTERY (fig. 631, 18), the vessel most commonly divided in suicidal wounds, passes forwards and downwards as a sinuous arch, which lies at first superficially under the integuments and fascia, on the superior laryngeal nerve and thyroid cartilage, then passing beneath the *omohyoid* and *sterno-hyoid* and *sterno-thyroid* muscles, it descends to end in the thyroid body. It gives off (1) an **infrahyoid** branch, which communicates with its fellow, forming an arch beneath the *thyro-hyoid* muscle, along the lower edge of the hyoid bone, and supplies the *bursa infrahyoidea*; (2) **sterno-mastoid** branch which descends across the sheath of the common carotid artery to end in that muscle; (3) **superior laryngeal**, which accompanies the superior laryngeal nerve beneath the *thyro-hyoid* muscle, through the thyro-hyoid membrane, within which it divides into ascending and descending branches, distributed to the neighbourhood of the epiglottis and vocal chord respectively; (4) **inferior laryngeal**, which crosses the crico-thyroid membrane close to the lower edge of the thyroid cartilage to join its fellow. It is only important as being endangered in laryngotomy. The terminal branches are usually three, an **internal**, **anterior**, and **external**, distributed to the thyroid body in which they anastomose with the inferior thyroid artery, forming therewith, and with their fellows, a series of three or four irregular arches in the substance of the thyroid body. From the internal terminal arise *posterior laryngeal* and *anterior tracheal* branches.

Two corresponding veins return blood from the thyroid body, a *superior thyroid vein* which accompanies the artery, lying below it, empties its blood into the common jugular vein, the second or middle thyroid vein runs outwards directly from the thyroid body across the common carotid to the common jugular vein; most of the blood of this body, however, escapes by the inferior thyroid veins (§ 506).

439. LINGUAL ARTERY (fig. 660, 6), the inner mandibular vessel, arises with the next above the level of the hyoid bone. It lies deeply and so cannot be properly followed until the sublingual space is dissected (p. 585). For convenience of description it may be divided into three stages—the *first*, as far as the outer edge of the *hyoglossus* muscle; the *second*, under cover of that muscle; and the *third*, in the substance of the tongue. In the first stage it ascends and turns inwards above the greater hyoidean cornu, and lies on the *middle constrictor* of the pharynx and superior laryngeal nerve, and is covered by the integuments and the descending facial and lingual veins and lymphatics. In the second stage it passes inwards beneath the *hyoglossus* muscle and hypoglossal nerve into the substance of the tongue. Here it courses tortuously forward between the *genio-glossus* muscle internally and the *lingualis* externally, above the mucous membrane on each side of the *frænum linguæ*, ending in the corium of the tip (*ib.*, 9).

It gives off (1) the **suprahyoidean** artery to the tissues in front of the epiglottis; this joins its fellow and the infrahyoidean branches of the superior thyroid; (2) the **dorsal lingual** branch, which supplies the mucosa of the dorsum of the tongue on each side of the calyceiform papillæ and the adjoining portion of the faucial pillars and tonsil; (3) the **sublingual**, which passes under cover of the *mylo-hyoid* muscle to the sublingual salivary gland and to the mucous fringes beneath the tongue, anastomosing with the submental artery.

The terminal portion of the lingual artery, which is accompanied by the lingual nerve, is sometimes called **ranine**.

Anastomoses between the vessels of opposite sides in the tongue take place only in the corium and by means of very small vessels. The lingual artery may be found for ligature above the greater cornu of the hyoid bone. There is seldom a single lingual vein, but each of the three branches of the artery is accompanied by a network of veins, whereof the sublingual joins the superficial and the two others join the deep facial vein. The ranine vein often lies close to the hypoglossal nerve, over the *hyoglossus*. The *dorsalis linguæ* vein is large, and accompanies its artery.

440. FACIAL ARTERY OR EXTERNAL MANDIBULAR ARTERY (fig. 631, 20) arises with or above the last, to which it lies superficial. It may, for convenience, be divided into two stages—a cervical and a facial. In the former it ascends under the integuments, *digastric* and *stylo-hyoid* muscles, some veins, and the hypoglossal nerve, to the lower border of the mandible, which it crosses in front of the *masseter* muscle. Here it can be felt pulsating during life. In this cervical stage in the adult it is often much curved as it passes first upwards behind the jaw for a short distance, embedded in the submaxillary gland, and then turns downwards to reach the edge of the bone. In this stage it lies on part of the submaxillary gland, which separates it from the *styloglossus* muscle.

On the face it ascends forwards towards the angle of the mouth, ending by sending a terminal branch into the ala of the nose. Here it lies *under* the *depressor anguli oris* and the insertion of the superficial radial muscles of the upper lip and *on* the mandible, the *buccinator* and the deep radial muscle of the upper lip, on which it usually anastomoses with a descending branch of the transverse facial.

The fetal facial artery is fairly straight, and it does not descend in an arch behind the mandible; in old age the artery becomes very tortuous.

In its cervical stage, the facial artery gives off (1) a **tonsillar** branch, which ascends between the *styloglossus* and *internal pterygoid* muscles to the tonsil; (2) several small **glandular** branches to the submaxillary salivary and submaxillary lymphatic glands; one of these partly accompanies Wharton's duct; (3) **muscular** branches to the *internal pterygoid* muscle; (4) **submental**, which passes inwards between the anterior belly of the *digastric* and the mandible to supply the superficial parts beneath the chin, anastomosing by three branches with the mental and sublingual arteries, and supplying the submaxillary gland and the *digastric*.

Having crossed the edge of the mandible, the facial artery gives off two **ascending buccal** branches which pass upwards over the *buccinator* to join the buccal and transverse facial arteries. It sends forward into the lower lip an **inferior labial** artery, which ascends beneath the *triangularis oris*, usually dividing into two branches, the lower of which (*superficial mental*) ends by joining the submental and mental vessels in the thickness of the lip, while the upper (*inferior coronary*) coats tortuously along the margin of the lower lip, nearer to its mucous than to its skin side, and joins its fellow medially. The **superior coronary** artery, larger than the rest, arises near the labial commissure, and passes towards the middle line along the lower margin of the upper lip, between the muscular and mucous layers. At the philtrum it bifurcates, one branch uniting with its fellow, the other ascending to the columna nasi (*arteria septi*).

The terminal branch of the facial artery or **lateral nasal** ascends over the nasal cartilages, beneath the nasal muscles, to end in the soft parts of the nose. An ascending **angular** branch is often continued upwards from it to join the nasal branch of the ophthalmic, and the transverse facial, this sometimes appears as though it were the termination of the facial artery.

In labial operations the deep position of the coronary arteries should be borne in mind, and hence the pins of the twisted sutures should be deeply sunk in the texture of the lip. The facial vein begins in an angular plexus communicating with the ophthalmic and middle frontal veins; it descends external to the facial artery, running a straight course to the mandible, which it crosses, having received the dorsal nasal, the lateral nasal, the inferior palpebral, the buccal vein (which communicates with the pterygoid plexus), the labial, submental, submaxillary, and sublingual veins. These veins have no valves; beneath the mandible the facial vein receives the ascending palatine and ascending pharyngeal vein, and ends by joining the temporo-maxillary vein.

441. ASCENDING PALATINE ARTERY (fig. 631).—This small vessel often arises by a common trunk with the facial artery, and passes upwards between the internal and external carotids, and between the *stylo-glossus* and the *stylo-pharyngeus* muscles, to end in the pharyngeal wall close to the outer surface of the pterygoid plates. It supplies *tonsillar* and *palatine* branches to the parts in the vicinity of the Eustachian tube.

442. THE ASCENDING PHARYNGEAL ARTERY (fig. 631) can only be seen at present as it arises from the deep surface of the commencement of the external carotid, between that artery and the vertebral column. Its subsequent course can be best traced in the dissection to exhibit the internal carotid artery (§ 484). It ascends beneath the *stylo-pharyngeus* muscle upon the vertebral column, having the pharynx to its inner side and the internal carotid artery and sympathetic nerve to its outer. Its branches are—**pharyngeal**, usually two, an upper and lower, to the middle and superior *constrictor* muscles and the parts related thereto, and to the inner side of the Eustachian tube; **pre-vertebral**, to the fasciæ and muscles in front of the spine; **meningeal**, which ascends through the posterior lacerate foramen in front of the jugular vein to the dura mater of the posterior fossa.

There is usually a second small **meningeal** branch which traverses the cartilage of the anterior lacerate foramen. A third branch, the **tympanic**, accompanies the tympanic branch of the *glosso-pharyngeal* nerve into its canal, and there traverses the curious pseudoganglion of that nerve (fig. 680). From this, in many animals, the **stapedial** artery which has pierced and so determined the shape of the stapes, is derived, but this vessel is never present in man. The ascending palatine and pharyngeal veins end in the pterygoid plexus.

443. THE STERNO-MASTOID ARTERY is small and somewhat irregular, but usually arises close to the level of the *digastric* muscle, along which it runs to its termination in the *sterno-mastoid*. The hypoglossal nerve winds round it as it is parting company with the *descendens cervicis*.

In size it is the reciprocal of the *sterno-mastoid* branch of the superior thyroid artery. It may come off by a common stem with the occipital artery.

444. THE OCCIPITAL ARTERY (figs. 620, 631) arises below, runs backwards along, and is overlapped by, the lower edge of the posterior belly of the *digastric*. In the first portion of its course it lies on the internal carotid artery, the vagus, and the internal jugular vein, and is covered by the integuments, crossed by the hypoglossal nerve (which hooks round it), and overlapped by the temporo-maxillary vein and the *digastric*. It then sinks beneath the *sterno-mastoid*, the origin of the *digastric*, the *trachelo-mastoid* and *splenius*, and lies on the *rectus capitis lateralis* and the grooved surface of the temporal bone, having the mastoid process above it, and the transverse process of the atlas below. Having touched the border of the *obliquus capitis superior*, it crosses that muscle, as well as the *complexus*, and having entered the triangular interspace formed by

the divergence of the *splenii*, it pierces the fascia which connects the occipital attachment of the *sterno-mastoid* and that of the *trapezius*, and enters the scalp. Here it ascends tortuously along the line of the lambdoidal suture through the *occipitalis* muscle along with the great occipital nerve, and ends in the scalp, anastomosing with its fellow, and with the two succeeding vessels.

In this long course it gives off **muscular** branches to the *digastric*, *stylohyoid*, *splenius*, *sterno-* and *trachelo-mastoid* muscles; **auricular**, to the back of pinna; **jugular**, which enters the jugular foramen behind the vein and ends in the dura mater; **descending**, the so-called *princeps cervicis*, which passes beneath the *splenius*, on the *complexus* to anastomose by its posterior descending branch with the cervicalis profunda by its anterior with the superficial cervical; **mastoid**, which traverses the mastoid foramen to the dura mater and mastoid cells; **communicating**, which joins the vertebral between the *rectus capitis lateralis* and the *obliquus superior*. Its terminal branches are usually two, **internal** and **external**; from the former the *parietal* branch, which enters the parietal foramen, is derived. The veins accompanying the terminal and mastoid branches end in the external jugular, those of the muscular and descending branches accompany the artery and join the temporo-maxillary.

445. THE POSTERIOR AURICULAR ARTERY (figs. 623, 631) arises above the level of the posterior belly of the *digastric* and opposite the tip of the styloid process; it ascends, behind the parotid gland, to the interval between the external auditory meatus and the mastoid process. Close to its origin it gives off **muscular** branches to the *digastric*, **parotidean** branches, and the **stylo-mastoid** artery. This last enters the aqueduct of Fallopius through the stylo-mastoid foramen, within which it gives off an *arteria meningea*, a *vestibular* and a *tympanic* branch, anastomosing in the hiatus Fallopii with a branch of the middle meningeal artery; and branches to the external auditory meatus. The terminal branches of the posterior auricular artery are two. The **anterior** supplies the front of the pinna, the **posterior** supplies the back of the ear and the skin over the mastoid process. The veins are two, and end in the temporo-maxillary.

446. THE TEMPORAL ARTERY (fig. 620) arises from the external carotid, as it is about to turn behind the ramus of the jaw, and ascends in the parotid gland beneath the upper temporo-facial nerves. Leaving the gland at the root of the zygoma, in front of the ear, it ascends over the temporal aponeurosis and under the *attrahens aurem*. About 3 cm. above the zygoma it divides into *anterior* and *posterior* branches; the former passes forwards in a sinuous manner to the temple and forehead. This vessel can be felt and even seen pulsating, being only covered by skin and a weak connective sheath derived from the cervical fascia, and it becomes tortuous in old persons. The posterior branch arches backwards and divides into branches which anastomose with the anterior and with the occipital. The temporal artery is closely beset with sympathetic filaments, which unite on it to form a large superficial temporal ganglion. It is crossed and accompanied by the temporo-facial nerve and lies over and behind the temporo-auricular nerve.

In the neck the temporal gives off four sets of branches—the *parotidean*, *masseteric*, *articular* to the joint of the lower jaw, and *auricular* to the tragus. Having passed over the zygoma it sends off a small but inconstant *middle deep temporal*, which arises 1 cm. below the bifurcation, pierces the temporal aponeurosis immediately above the zygoma, and supplies the underlying muscle (fig. 620, *Mdt*). It also gives off the *zygomatiko-orbital* which supplies the parts above the external canthus, and the *anterior auricular*, which supplies the *attollens aurem* and its vicinity.

447. THE TRANSVERSE FACIAL ARTERY usually arises by a common trunk with the temporal, but passes transversely forwards through the parotid gland, emerging at its anterior or facial border beneath the *socia parotidis*, above Stenson's duct and below the infraorbital branches of the facial nerve. It sends off *masseteric*, *parotidean*, and *angular* branches, the last of which anastomoses with ascending branches of the facial, and with branches of the infraorbital artery, emerging through the infraorbital foramen.

448. THE INTERNAL MAXILLARY which is the continued trunk of the external carotid, cannot be seen until a later stage of the dissection (§ 462).

449. VENOUS TRUNKS.—Most of the secondary branches of these trunks have only a single accompanying vein (fig. 628).

The veins accompanying the primary branches of the external carotid are a little variable in their mode of uniting. The facial vein receives a large *deep facial* communicating branch

from the pterygoid plexus, in front of the *masseter*; below the body of the jaw it receives the posterior facial (from the pterygoid plexus), lingual, submaxillary, and submental veins, and emerges from beneath the submaxillary gland to join the temporo-maxillary vein.

There are two *venæ comites* for each branch of the temporal artery, but these coalesce into one large superficial *temporal vein* behind and overlapping the artery. This receives a large *zygomatico-orbital* and a *deep temporal vein* from the temporal muscle, crosses the root of the zygoma, and dips into the parotid gland superficial to the artery, there to receive the *transverse facial vein* and to join the *internal maxillary vein* (§ 463), forming the *temporo-maxillary*. The combined trunk emerges at the lower edge of the gland, sends downwards and backwards a

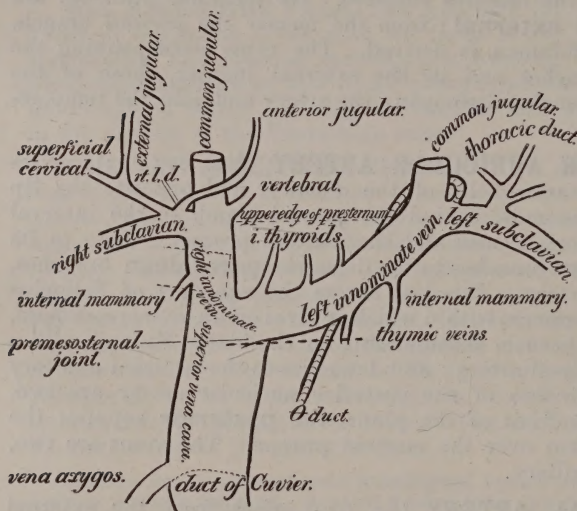


Fig. 638.

large communicating branch to the external jugular, which crosses the *sterno-mastoid* muscle obliquely. The *temporo-maxillary vein* terminates by joining the common facial vein. The common *temporo-facial* stem thus formed unites at once with the *internal jugular*, to form the *common jugular vein*.

The **internal jugular vein** begins at the *bulbus jugularis* in the jugular fossa, and descends at first behind the internal carotid artery, from which it is separated by the *glosso-pharyngeal*, *vagus*, and *hypoglossal* nerves, and by the hinder part of the carotid plexus of the sympathetic. It then passes to the outer side of the artery, in which position it descends to the level of the bifurcation of the common carotid artery. At the *bulbus* it receives the blood of the inferior petrosal sinus (fig. 618, 6), and near the angle of the jaw it receives the two veins emerging from the pharyngeal venous plexus, draining the blood from the hinder wall of the pharynx. Opposite the bifurcation of the carotid the internal jugular joins with the *temporo-facial vein*, and forms the **common jugular** which descends along the outer side of the common carotid artery to its termination in the *vena innominata* (fig. 638). It has a double valve about 3 cm. above its lower end. In point of size the right jugular usually exceeds the left, and the combined sectional areas of the two jugular veins are to those of the carotids as 20 : 11.

CEPHALIC PORTION OF THE DIGESTIVE TRACT.

450. THE OPENING OF THE MOUTH is bounded by soft mobile lips, whose appearance (p. 523) and musculature (p. 536) have been already described. In the closed mouth the level of the **rima** is opposite the middle of the upper teeth and the angles of the mouth are opposite the first bicusps. The length and thickness of the free lip varies with age, race, and sex; in the infant the margin is divided into two zones, an outer or smooth zone and an inner, softer, or villous zone. The median tubercle of the upper lip, the remnant of the free end of the fronto-nasal process, is more pronounced in the infant than in the adult.

The mucosa of the red margin and inside of the lip is clothed with a thick, stratified epithelium translucent from the absence of eleidin, whose surface cells are flat, and the deep cells often much ribbed. This embeds the numerous vascular and sensory papillæ so that they do not project on the surface; sebaceous glands without developed hair-bulbs extend for a short distance on the red margin. The sensibility of the lips is such that the blades of the æsthesiometer can be separated for 4 mm. on the red edge, 9 mm. on the skin below the red edge, and for 17.5 mm. on the inner side of the lip. The papillæ become smaller internally as they become remote from the edge.

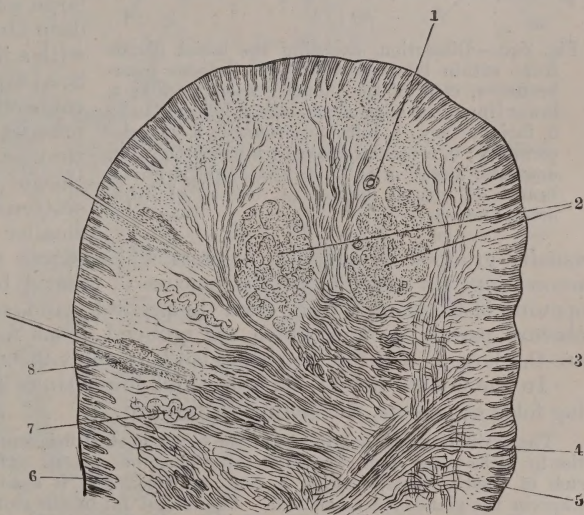


Fig. 639.—Sagittal section of lower lip—1, coronary artery; 2, glands; 3, orbicular fibres of buccinator; 4, fibres of musculus labii proprius; 5, papillæ of mucosa; 6, papillæ of skin; 7, sweat gland; 8, hair follicle.

The lip consists of muscle, connective tissue, and glands between the layer of skin without and the mucosa within (fig. 639). The labial glands are racemose mucous glands, which are arranged in an irregular zone, becoming fewer towards the angles, but more numerous towards the centre and in the upper lip than in the lower; they are embedded in a dense submucous tissue in which many muscular fibres end (fig. 640). Their ducts are narrow, sometimes twisted. In the lips are to be found the coronary arteries, a thin-walled, wide-meshed plexus of veins, a wide subcutaneous network of lymphatics, and numerous filaments of the infraorbital nerve in the upper, and of the mental nerve in the lower lip (*ib.*, 13, 14).

451. VESTIBULUM ORIS (fig. 641).—The cavity whereinto the rima leads is bounded peripherally by the lips and cheeks, centrally and internally by the teeth and jaw arches, above and below by the sinus labiorum or angle of reflection of the mucosa, from lips to gums, and posteriorly by the pterygo-mandibular mucous fold, which clothes the front of the coronoid process and the fibrous structures extending therefrom to the pterygoid plates. This is a slit-like space when the mouth is closed, and into it open the ducts of the labial, buccal, and molar glands, and Stenson's duct from the parotid.

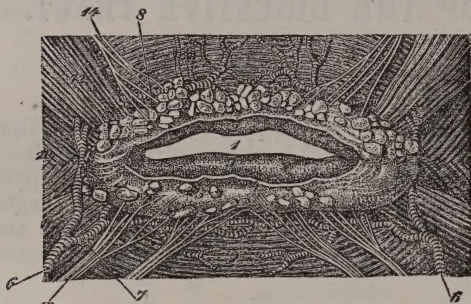


Fig. 640.—Dissection, exposing the labial glands from within by removal of the mucous membrane—1, cleft of the mouth; 2, upper lip; 3, lower lip; 4, cut edge of mucosa; 5, labial glands; 6, facial artery; 7, inferior coronary; 8, superior coronary; 9, orbicular fibres; 10, buccinator; 11, depressor anguli oris; 12, levator anguli oris; 13, branch of mental nerve; 14, branch of infra-orbital nerve.

452. THE CHEEK consists of skin which differs from that of the lips in having no muscular fibres inserted into it; a subcutaneous muscular lamella formed by the *zygomatrics* and *risorius* (fig. 620); a definite fatty layer of large soft encapsulated granules; a deep muscular layer, the *buccinator* with a fibrous sheath on its superficial aspect, and a firm submucous connective layer attached to the muscle within. The mucosa is thinner and less sensitive than that of the lips, and studded with scattered glands similar to, but smaller than the labial, and

usually grouped in irregular clusters whose ducts may unite. Opposite the second superior molar tooth the mucosa is pierced by the small oblique oval opening of **Stenson's duct** from the parotid gland, sometimes raised on a very obscure papilla, around which are grouped about five **molar glands**, which are the largest of the submucous glands in the vestibule.

In the middle line of the upper and lower sinus labiorum there are projecting folds of mucosa, the **fræna labiorum**.

The epithelium of the mucosa of the cheek is stratified squamous, sufficiently coherent to rise in blebs when fluid exudation takes place beneath it. The underlying tunica propria is rich in elastic fibres, making a close network, and it shades into the submucous tissue wherein the glands are embedded. The buccal fat in the child forms a lobulated, capsuled, and tallowy sucking-pad, which can be removed as a whole; it is quite independent of the subcutaneous fat, and is supposed to assist in sucking. When this persists as a large soft mass it gives a roundness to the cheeks as in young persons, especially in females; its atrophy causes the falling in of the cheeks as in wasting diseases.

453. THE GUMS (gingivæ) are dense masses of reticulated connective tissue, clothing both surfaces of the alveolar arches, to the periosteum of which they are inseparably adherent, and sending processes between the teeth. These interdental bridges are of varying breadth, those between the premolars being usually the widest. Around each tooth the gum-margin is papillose, and its secretion (*tartar*) consists of a semifluid material, rich in mucous corpuscles, and containing entangled in it epithelial scales, salivary salts, fragments of food, and developing, when undisturbed by the brush, a copious vegetation of *Leptothrix buccalis*.

Along this margin a red line of vascularity is often conspicuous in phthisis (Thompson's line), and the blue line of lead sulphide in cases of lead poisoning (Burton's line). Tartar, when copious and blackened by exuded and altered blood pigment, becomes *sordes* in typhus. The gum contains few nerves, numerous plexiform vessels with peculiarly dilated capillaries, and no muscularis mucosæ.

The lips serve as organs of suction, of prehension, and of speech. The cheeks retain the food between the teeth chiefly by their elasticity, but to some extent by the action of the *buccinator* muscle, hence in facial paralysis the food tends to accumulate between the teeth and the cheek. They modify the outgoing vibrations of air in speech. The fibres of the *musculus labii proprius* are more distinct and distinctly innervated in the lower lip (fig. 639, 4), and are concerned in the production of the sounds of F and V (English) by the approximation of the inner edge of this lip to the upper incisors, and in the production of the English W by the sudden depression of the lower lip from the passive upper; the converse position of the lip being necessary for the production of the nasal sound M. In the production of the other labial letters, B and P, the muscles which divaricate both lips

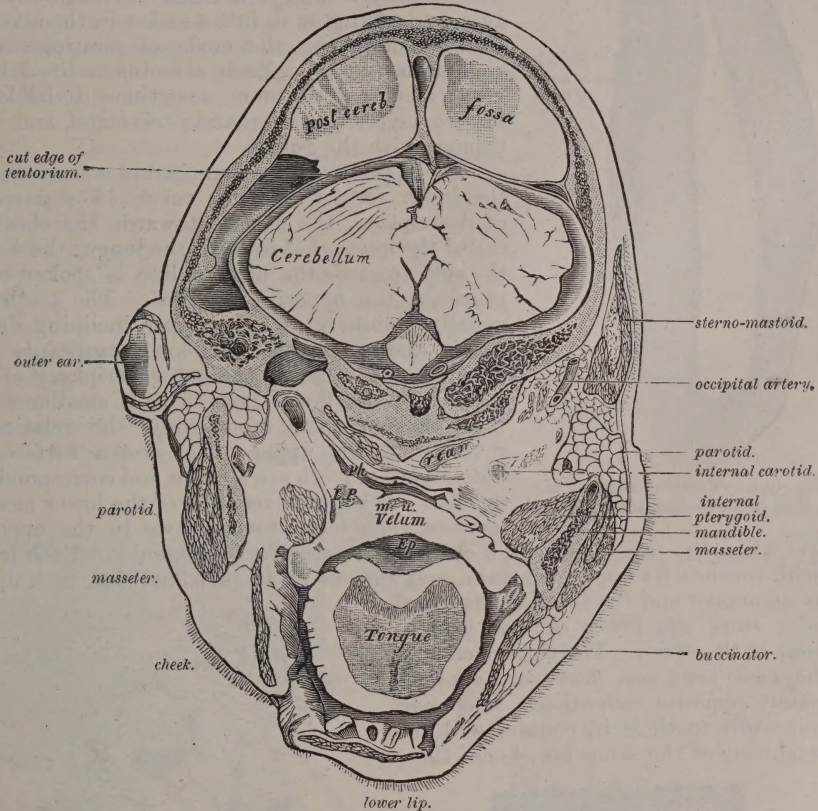


Fig. 641.—Horizontal section of head on the level of the upper edge of the lower lip, $\frac{1}{2}$ —*Ep*, epiglottis; *L.P.*, levator palati; *m. u.*, motor uvula; *rcam*, rectus capitis anticus major; *Ph*, naso-pharynx.—The section is that of an old subject in whom all but a few of the front teeth had fallen out, hence the distinction between the vestibulum and cavum oris is small.

take part. The large vessels of the cheek are superficial to the *buccinator*, but beneath the muscle there are two planes of fine vascular plexuses, one in the submucous tissue about the glands, the other in the tunica propria. Fibrinous exudations from these vessels beneath the epithelium constitute one form of aphthæ. The density of the gum-tissue is the cause of the pain in gumboil.

To see the vestibulum oris, divide the lips at their outer third vertically, and cut the cheek horizontally along the sinus labiorum above and below, and reflect it from the mouth backwards.

454. THE TEETH are calcified papillæ, which have originated in the mucous membrane, and around whose bases the sockets and gums have grown up.

In the adult, when the dentition is perfect (a rare condition in civilised man), they are bilaterally symmetrical, thirty-two in number—eight above and eight below on each side. The four central teeth in each jaw are called *incisors*; the tooth which lies external to these on each side is the *canine*; the two succeeding teeth are *premolars* or *bicuspsids*; the three hindmost are *molars*.

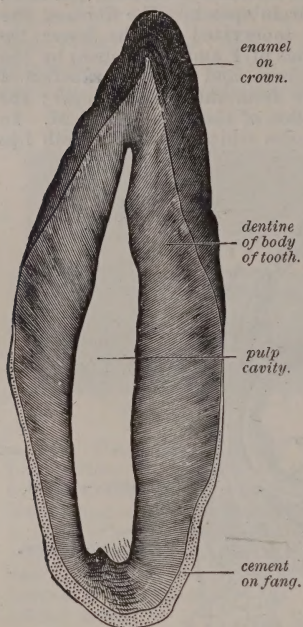


Fig. 642.—Vertical sagittal section of an incisor tooth, $\times 4$.

The upper teeth are arranged in a semi-ellipse; the lower form a parabolic curve. For purposes of description, the surface towards the cheek is called the *outer*, that towards the tongue the *inner*; the side towards the median line is spoken of as *proximal*, the opposite as *distal*. The teeth are usually obliquely set, the upper inclining downwards and outwards, the lower upwards and inwards, consequently the outer periphery of the crowns in the lower jaw forms a smaller curve than that of their roots, while the relation is reversed in the upper. The crown surfaces of both arches of teeth are sinuous and corresponding, not flat. With the exception of the lower median incisors, each tooth touches two in the opposite jaw when the mouth is shut, a chief and an accessory antagonist. Each lower tooth touches its upper namesake and the one on its proximal side, each upper its namesake and the tooth on its distal side; thus, the lower canines bite in front of the upper. The third molars of the two jaws are, however, approximately opposite each other. Each normal adult tooth is in contact with its neighbour of the same jaw, hence there

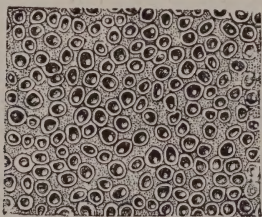


Fig. 643.—Transverse section of dentine. The light rings are the cut dentine tubules containing the processes of the odontoblasts, represented as the clear contained spots (fibres of Tomes).

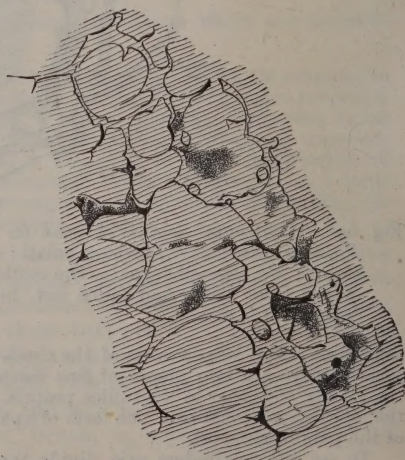


Fig. 644.—Interglobular spaces in the dentine, $\times 200$.

are usually *friction facets*, proximally and distally, except on the back of the last molar. The wear of the surfaces is unequal; the hinder tubercles

of the upper and the front tubercles of the lower show most signs of attrition.

Each tooth consists of a hard calcified outer substance and a soft inner pulp. The *pulp cavity* wherein the latter is contained is in shape like a miniature of that of the tooth, and is entered by a minute *pulp canal* which perforates the fang.

The **pulp** is a gelatinous mass of branched stellate and fusiform cells, united by short processes. Between these *odontoblasts* are vessels and nerves. The mass of the hard outer substance consists of **dentine**, or ivory (fig. 643), a connective tissue harder than bone and consisting of a homogeneous ground-substance, permeated by closely set *dentine tubules*, which contain fine outgoing processes of the odontoblasts. These tubules start from the pulp cavity, are about $25\ \mu$ in width and $95\ \mu$ apart. Each is lined by a firm *dentinal sheath* of keratin. The dentinal tubes present primary and secondary wavinesses, send off fine branches towards the surface, which are often grouped in bundles, and communicate externally in the outer part of the dentine with irregular *interglobular spaces* (fig. 644) containing globules and granules of dentine. The specific gravity of dentine is 2.08, and it contains about 28 parts of animal matter to 72 of earthy. Wavy *incremental lines*, consisting of minute dentine granules, irregularly packed in a homogeneous basis, traverse the dentine, showing stages of growth.

The crown of each tooth is covered with a cap of **enamel** (fig. 645) which is the hardest substance in the body, resembling Arragonite in texture (5 in the scale of hardness and 2.98 in sp. gr.). It consists of long, semi-transparent, hexagonal prisms, 3 to $4\ \mu$ in diameter, closely pressed together and radially disposed, with one end on the dentine, the other

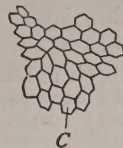


Fig. 645.—Transverse section of enamel prisms, $\times 500$ —C, a single enamel column.

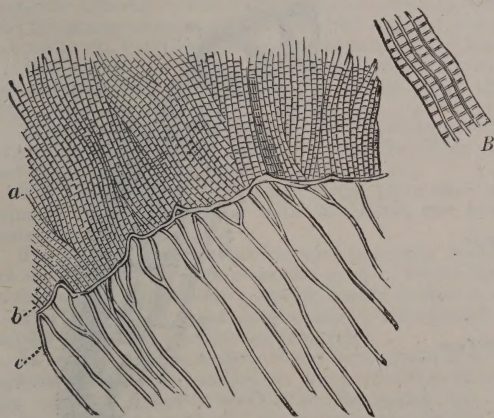


Fig. 646.—Vertical section of enamel, $\times 250$ —a, enamel prisms; b, boundary line, with irregular spaces; c, dentine tubes; B, four enamel prisms, $\times 500$.

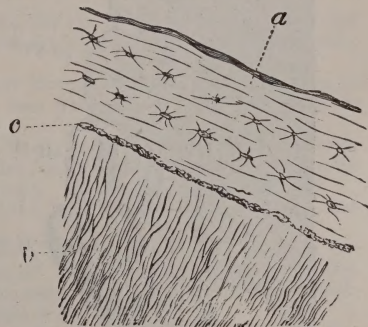


Fig. 647.—Transverse section of tooth-fang, $\times 150$ —a, cement; b, dentine tubes; c, boundary zone.

directed towards the surface (fig. 646, a). The columns are often a little irregular, wavy, united by a minimum of cement substance, and superficially invested by a thin but very resisting layer, the **enamel cuticle**. Each enamel prism presents an alternation of clear and dark lines (*ib.*, B). The columns are vertical and look pavement-like when viewed end on. The thickness of the enamel layer is variable; it is thickest on the crown of each tooth, thickest of all on that of the upper median incisors (1.5 mm.). It thins

towards the neck, and ends along an abrupt line. In the teeth of Europeans the enamel presents flaws or deficiencies, cooking having minimised the work for which its existence was primitively necessary. The modulus of elasticity of enamel is 4,500; that of dentine, 6,200.

The fang of each tooth is covered by a layer of true bone, called **cement**, formed beneath the periodontal membrane, and containing lacunæ and canaliculi (p. 36), and, in rare cases in the fangs of the canines of old persons, one or two Haversian canals. This coating thins towards the neck of the tooth.

Each **incisor** tooth is convex externally, concave or flat internally, with a flattish chisel-shaped crown, and a single conical fang slightly furrowed on one or both sides. Before being worn, the median incisors have a three-pointed crown, and usually the upper overlap the lower, except in persons with undershot jaws. In laughing, the upper incisors are exposed (hence γέλ. αὐστηρί) not the lower.

The upper median incisor, length 25 mm., is large, bevelled inwards at the crown. The fore and aft convex enamel boundary lines meet at an obtuse angle. The proximal angle of the crown is a right angle; the distal is rounded. The upper lateral incisor, length 22 mm., has a smaller crown and a laterally compressed fang. The two angles tend to converge at half the length of the crown, and the distal angle is much rounded. The lower middle incisor (21 mm.) is the smallest tooth, placed vertically, bevelled outwards, scarcely convex externally, and the inner enamel triangle diverges from its fellow below.

The lower lateral incisor is smaller than its upper fellow, with a broader crown and a slightly elongated outer angle.

Each **canine** tooth has a single strong fang, and the crown is pointed, sagittally thicker than the crown of the strongest incisor, is slightly hollowed

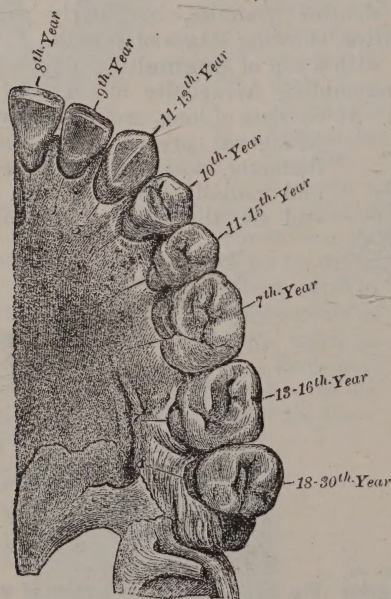


Fig. 648.—Crown surfaces of the teeth in the left half of the upper jaw, with the dates of eruption.

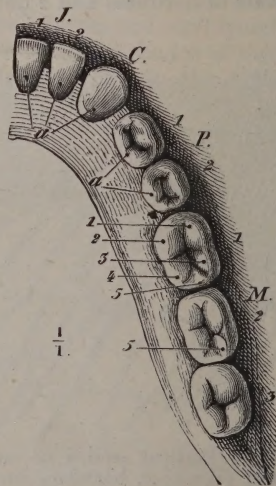


Fig. 649.—Crown surfaces of the teeth in the lower jaw.

behind, and convex in front. Its fang, which is longer than that of any other tooth, has a lateral groove. It sometimes enters the antrum.

The crown of the *upper canine* is a three-sided pyramid, whose proximal face is larger than the distal. There is often a little tubercle on the inner side. The *lower canine* is smaller, with a blunter point and a shorter root; but its crown is a little longer than that of the upper. The lingual tubercle is distinct, but small (fig. 649, a). In both canines the pulp cavity ends above in a single point.

Each **premolar** presents two cusps or tubercles on the crown, an outer and an inner, and a single fang often divided into two at its point, and with two pulp canals. The crown groove between the tubercles bifurcates in front and behind, thus bounding small proximal and distal tubercles.

The upper premolars have the two cusps nearly equal; the strongly marked distal wall of the cheek cusp is often marked by a middle ridge never seen on the tongue cusp. The proximal portion of the cheek tubercle is longer than the distal, and its highest point is posterior, while that of the tongue cusp is anterior.

These characters are more distinct on the first than on the second premolar. The former is rounder in horizontal circumference, the latter is more flatly compressed, its diameter from within outwards being a little greater than that of the first. The two tubercles are subequal on the hinder.

The first lower premolar has a faint crown-furrow, consisting of two pits, one proximal and one distal, joined by a very slight furrow, which is concave outwards, nearly obliterated in the middle. The distal part of its lingual cusp is the higher and sharper point, but the cheek cusp is the larger and more pointed. The hinder, lower bicuspid premolar has a similar, but better marked, crescentic crown-furrow, which tends to bifurcate posteriorly.

The **molar teeth** are the largest in size, their crowns present from three to five cusps, and each tooth has from two to four fangs. The upper molars are obliquely placed, their planes of separation lying along lines radiating from the posterior palatine spine to the alveolar arch. Each upper molar has usually a sharply marked outer and an obtuse inner margin; each lower has a sharper inner and a more obtuse outer. Each lower molar has usually two flattish fangs, one proximal the other distal, and both strongly bent backwards at their lowest ends. Each upper molar, as a rule, has three fangs, two smaller external and one larger internal.

The crown of each upper molar is rhomboidal. That of the *first*, the largest tooth, is marked by an H-furrow inscribed on the rhomboid, whose acute angles are antero-external and postero-internal, dividing its surface into four cusps, a large anterior internal, a small posterior internal. The cheek cusps are smaller, higher, and sharper; the anterior internal and the posterior external are united by a ridge; and a rudimental fifth cusp, which does not extend to the functional surface, is present on the inner side of the hinder inner cusp.

The *second upper molar* is the most variable tooth, and usually presents only three cusps, two external and one internal, the hinder outer cusp being the smaller. Its outer fangs often coalesce.

The *third upper molar* has usually three cusps, either like the last, or with one outer and two inner tubercles; its roots are irregular, often clubbed; it is the smallest molar tooth, and never has a hinder interdental facet.

The *lower first molar* has five cusps, three outer and two inner, and its proximal fang is thinner, flatter, and wider than the distal, and has two pulp canals. The fifth cusp is postero-external.

The lower second molar has also two pulp canals in its proximal fang; its four cusps are separated by an even cross-like groove, whose hinder limb is often bifurcated, especially in the jaws of Australians; and its hinder surface is round.

The lower third molar has no hinder interdental facet, has its outer angle rounded, and usually has a fifth postero-external cusp.

In comparing the crowns of the several series of teeth it is to be noted that even in the incisors there is a tendency to the production of lingual as well as cheek tubercles (fig. 649, a); this is better marked on the canine and becomes functional in the premolars, whose crown represents the whole triangular lingual field of the incisor.

The human jaw has a continuous row of teeth, as the alveolar arch is short and the canine teeth are of small size. In other animals with a proportionally longer arch the overgrowth of the canines in one jaw by displacing the opposed teeth causes a corresponding gap in the opposite jaw, which is called the diastema.

The sizes of the teeth vary in different races, being small in Europeans, ancient Egyptians, and other civilised races, familiar for generations with arts of cookery for softening food, and diminishing the necessary energy of mastication, whereas they are large in Negroes and Australians. A numerical parameter may be obtained by comparing the collective lengths of the crowns of the molar and premolar teeth, with the length of the basicranial axis.

When the
$$\frac{\text{dental length} \times 100}{\text{basinasal length}}$$
 exceeds 44 the skull may be considered as macrodont, if under 42 microdont, if intermediate, mesodont. This index is always higher in females than in males.

Development of Teeth.—In the second month of foetal life a continuous thickening of the mouth-epithelium sinks into and fills a *groove* along each jaw-arch. This epithelium is the *common enamel-germ*. The corium rises as a ridge in front and behind this groove, which appears pear-shaped in vertical section; and ridges of corium rise at intervals along the floor of the groove dividing it into a series of pits filled with epithelium, the mouths of which, in process of time, become narrowed. The masses of epithelium in these separate pits are called *special enamel-germs*. At the bottom of each of these *dental follicles* a small vascular papillary process of corium rises, jutting into the mass of epithelium. This is the *tooth papilla*, and it consists superficially of soft branched connective cells (odontoblasts). The layer of epithelium in contact with the papilla becomes adherent and forms the *enamel epithelium*, and the tubular neck whereby the epithelium of the follicle was connected with the surface epithelium becomes closed, the follicle becoming a sac. The peripheral layer at first lines the follicle, and the intermediate layer becomes gelatinous and degenerated, and finally vanishes as the papilla enlarges. The intercellular substance around the peripheral processes of the odontoblasts becomes calcified as dentine, tubulated because traversed by the filamentary processes of the cells, and the bodies of the cells are displaced farther and farther inwards, becoming ultimately the central pulp mass within the dentine. This dentine at first forms a cap to the papilla, upon which the enamel forms a second cap, but as growth proceeds,

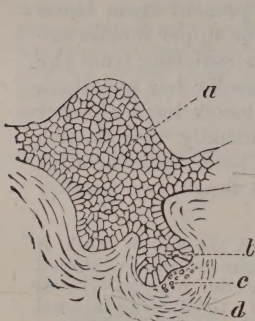


Fig. 650.—Diagram of early stage of the development of a tooth papilla—*a*, epithelium of dental ridge on lower jaw; *b*, portion of epithelium about to be modified into enamel (enamel organ); *c*, beginning of germ of dentine in the tooth papilla; *d*, lamina of corium about to form tooth sac.

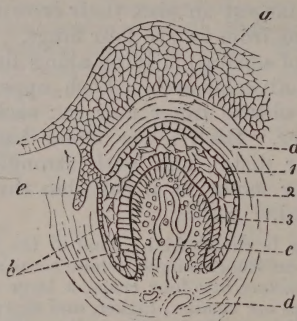


Fig. 651.—Second stage of tooth-development—*a*, dental ridge; *b*, enamel organ, now divided into three layers—1, a superficial lining the tooth sac, 2, a middle gelatinous layer, whose cells have become stellate, 3, the layer becoming enamel prisms; *c*, papilla of tooth, with vessels of pulp and elongating osteoblasts on the surface; *d*, tooth sac; *e*, secondary enamel germ.

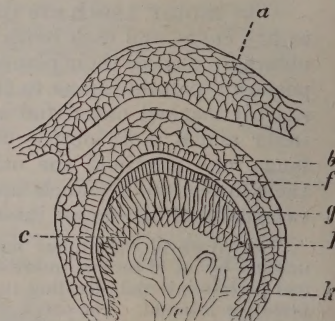


Fig. 652.—Later stage, showing—*g*, dentine; *h*, interval between the uncalcifying part of the enamel organ and the calcified surface of the enamel (*f*); *k*, layer of odontoblasts.

the dentinisation extends downwards, isolating the papilla to its base until finally all the odontoblasts are contained within a tubular dentine cavity, through whose wide down-directed mouth the vessels enter. In later stages this tube below narrows to become the pulp canal in the fang, and the nutrition of the tooth is thereby restricted. The first papilla appears in the fourth follicle from the middle, the second in the third from the middle, and both these are present at the end of the second month; the innermost papilla appears in the eighth, and the second papilla in the ninth week, the fifth is the last to appear, but is distinct about the middle of the third month.

By the time the dentine begins to calcify, the wall of the tooth follicle has become definite and condensed into a dental sac, into whose sides ossification extends gradually from the jaw, forming the alveolar arch. This appears at first as a continuous bony gutter, and the bony partitions are of later growth. The dental arteries and nerves lie at first in the floor of this groove beneath the dental sacs. The period of dentinisation varies in the teeth. The median incisor usually becomes dentinised and the enamel cap begins to calcify, in the third month. For each tooth dentinisation begins separately in each cusp. As the tooth approaches full development the wall of the bony cavity becomes absorbed, consequent on the upward pressure of the tooth. The gum becomes first thin and sharp-edged, then rounded, softened and swollen, then absorption takes place, especially over the

cusps, which protrude through the purplish gums as white points. The first tooth to appear is the lower medial incisor (seventh month after birth), then the central upper incisor (eighth month), then the upper lateral incisor (eight to tenth month), then the lower lateral incisors (tenth to twelfth month); then the first pair of temporary molars (fourteenth month), then the canines at seventeen months, and the second pair of temporary molars at twenty-two months. As the tooth fills the sac before cutting, the peripheral layer of epithelium cornifies into the enamel cuticle, and the uncalcified tissue around the root of the papilla when the alveolus has become perfect, becomes the periodontal membrane, and gives rise to the cement which is only ordinary bone. These dates are liable to individual variety, but the order is very constant. Rarely the incisors are cut at birth, as in the cases of Richard III., Louis XIV., Cardinal Mazarin, and Mirabeau.

Permanent Dentition.—Behind the follicle of each of these teeth of the first or deciduous dentition a small tubular diverticulum extends backwards from the neck of the sac (fig. 651, e). These secondary dental follicles appear about the fourth month and rapidly extend backwards, and at the fundus of each a tooth papilla appears, of the same nature as that in the first tooth sac; around this the alveolus ossifies, forming a socket, which is separated by a bony partition from the temporary tooth socket, and communicates with the surface by a solid pedicle traversing a canal in the bone, which opens behind each milk tooth. Coincidentally with the growth of the permanent tooth below, the pulp of the milk teeth becomes dentinised, the

milk tooth fang and alveolus become first horny and then absorbed, partly by pressure, partly by the phagocytic action of osteoclasts (p. 39), and the tooth finally is shed, the permanent tooth taking its place. The two incisors are succeeded by two permanent incisors, the canines by permanent canines, the temporary molars are succeeded by the premolars.

At the hinder part of each jaw-arch, from the end of the enamel ridge, three additional follicles form. The first, about the beginning of the fourth foetal month, is the germ of the first permanent molar; seven months after birth the follicle for the second molar appears, and at the end of the third year that for the last molar.

These papillæ calcify in the following order—the lower first molar at the sixth month after birth; the upper first molar and central incisors, upper and lower, at eight months; the lower lateral incisors at the ninth month; the lower canine and upper lateral incisor at nine and a-half months; the upper canines at ten months. The premolars are variable in succession, but all calcify between the fourteenth to the seventeenth month, the second molars about five years, the third molar about ten. The first permanent molars are cut at six years, and hence are called the “six-year-old molars.”

At six years of age there are thus forty-eight calcified teeth in the head, and at seven years the central permanent incisors replace the temporary which are then shed; at eight years the lateral permanent incisors succeed their predecessors, and between nine and ten the bicuspid replace the milk molars. The permanent canines appear at eleven, and the second molars (“twelve-year-old molars”) at twelve. The third molars or wisdom teeth appear at a variable period, usually about twenty.

Man is thus slower than any other animal in perfecting his dentition, and growth-changes take place in the jaws *pari passu* with these changes in the teeth. How much of the detail of the anatomy of the head depends on the size, shape, and use of the teeth, a little thought will show. The mechanical arrangements for the motion of the jaw, for receiving the impact of the mandibular teeth, for protecting the orbit from the masticatory concussions, &c., all these vary with varying size and use of the teeth. There is evidence that in civilised man the alveolar arch is shortening from diminished use, owing to improved cookery, and

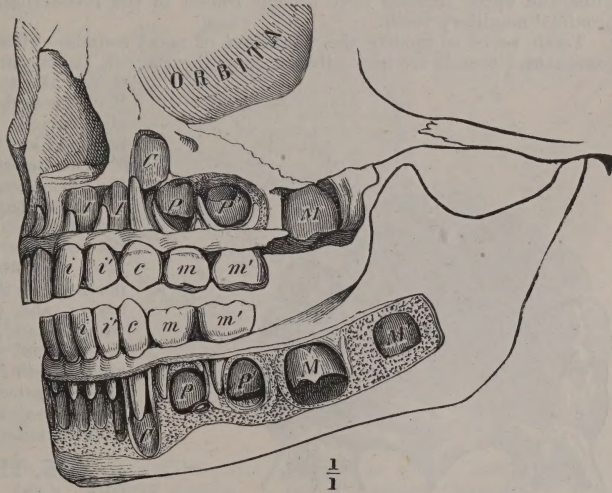


Fig. 653.—Alveolar arches of a child five years of age, with the surfaces removed to show the uncut permanent tooth-germs.

it has been recommended to provide for this and to prevent overcrowding, and the consequent dental mal-nutrition and disease, by the extraction of the six-year-old molar. This is merely anticipating the natural abortion of a tooth; but the teeth that naturally are tending to disappearance are the third molars which are absent in 12 per cent. of persons.

In old age the gums shrink, and often stumps which have been buried come to the surface, giving rise to the stories of tertiary dentitions, authenticated cases of which are extremely rare.

Not uncommonly, accessory nests of enamel epithelium are persistent in little closed follicles in the gum, but without papillae. Occasionally, a similar nest develops on a papilla in the mesopalatine suture, forming the not uncommon irregularity of a mesopalatine tooth. In man, the third incisor which is generally present in the other mammals has become aborted, but is occasionally present as a supernumerary tooth.

It must be remembered that teeth are simply special cases of dermal papillae, and so are comparable with such other papillae as those of the hair follicles, and are similar to those which form the cutaneous armature of placoid fishes. They are the papillae of the integument clothing the borders of the oral slit, and were originally in several rows. The double series in man is simply the delayed development of a hinder row. In shape, the homodontal condition was the primary one, and all the specialisations of form are derived therefrom. The relations to the bones are also secondary, although they have become very constant. Thus, the upper incisors have become rooted in the premaxilla, and the canines are the proximal maxillary teeth.

Teeth serve to modify the vibrations of vocal sounds. Hence, without teeth, certain consonantal sounds are impossible, such as the English Th, the French J, the sharp sibilant S, and the anterior forms of D and T.

With irregular teeth, vocal sounds are also varied, and certain modifications become likewise difficult of production.

The individual milk teeth can, like the permanent, be discriminated.

Dissection.—The integument has already been removed from the space between the ear and the ramus of the jaw. Remove now carefully the upper portion of the cervical fascia in this region, and expose the surface of the parotid gland, taking care of the branches of the facial nerve which are seen emerging from its front and lower margin, and ramifying over the face. Define the margin of the gland and of the duct emerging from its anterior border (fig. 614).

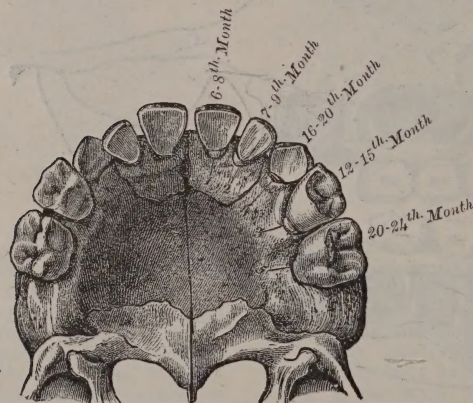


Fig. 654.—Alveolar arch of upper jaw; deciduous teeth seen from below, with the dates of their eruption. The premaxillo-maxillary suture is shown below 2.

muscles and fascia attached thereto in front. It overlaps, by its thin irregular anterior border, the hinder edge of the *masseter*, and is bound in its place by the strong layer of the cervical fascia which flattens its surface. Through this edge the branches of the facial nerve emerge. When cleaned this surface appears marked out into small flattened lobules. Above, the gland rises to the level of the root of the zygoma; below, it is bounded by the posterior belly of the *digastric* (fig. 624).

The parotid is traversed by the second stage of the facial nerve (p. 576), by the temporo-maxillary vein (p. 564) and temporo-auricular nerve, and by the external carotid artery (p. 559). Its vessels come from the external carotid and temporal arteries, its nerves from the sympathetic and from the glossopharyngeal, a branch of which reaches the gland circuitously, its fibres passing in the lesser petrosal cord and through the otic ganglion (§ 480; fig. 666), thereby reaching the auriculo-temporal by which they are brought to the gland. Embedded in its anterior surface are three small lymphatic glands.

455. THE PAROTID GLAND

(fig. 655), the largest of the salivary glands, lies in the irregular space between the ear meatus and mastoid process behind, and the ramus of the jaw and the

Its irregular deep surface is pressed against the styloid process and the stylo-mandibular ligament which separates it in front and below from the submaxillary gland. Owing to the irregularities of its surroundings the gland presents on its anterior and deep surfaces four projecting lobes. One, the *socia* (fig. 655) lies on the *masseter* muscle above the duct and the supramaxillary branches of the facial nerve, below the zygoma, and overlaps the transverse facial artery. It is usually fairly distinct, and sends a separate duct into the duct of Stenson. The deeper lobes are processes whose degree of distinctness depends largely upon the skill of the dissector, and should be shown later by a piecemeal removal of the gland. The **glenoid lobe** is the part which fits against the vaginal process of the tympanic bone, behind the capsule of the lower jaw in the part of the glenoid cavity behind the Glaserian fissure; the **pterygoid lobe** projects forwards behind the rami of the jaw and between the two *pterygoid* muscles, internal to the internal maxillary artery; the **carotid lobe** projects around the base of the styloid process, in the interval between the two carotid arteries, its deep surface resting on the internal carotid artery and jugular vein.

The **duct of Stenson** is formed by the union of several lobular ducts, and appears as a firm white tube, which leaves the gland at its anterior edge and crosses the *masseter* horizontally 1 cm. below the zygoma, running along a line drawn from the ear meatus to the mid-point between the ala of the nose and the angle of the mouth; at the middle point of this line it opens into the mouth (p. 566), having crossed the front edge of the *masseter*, where it is palpable during life, and having sunk through the buccal fat and pierced the buccinator muscle.

This duct is 6 cm. long and 3 mm. in diameter; it consists of a firm, fibrous adventitious coat, which, at the opening, is lost in the buccinator fascia; under this is a longitudinal connective layer, rich in elastic fibres, placed over a thinner circular layer, mainly also elastic, beneath which is a basement layer lined by a single stratum of columnar epithelium. Its lumen is .9 mm. in diameter, but it narrows to its elliptic orifice, which measures .6 along its long axis. The volume of the parotid is 26 cubic centimetres, its weight 27 grammes, and its specific gravity 1.05.

The parotid is an *aquaporous* compound *racemose* gland (p. 23) whose acini are irregular and alveolated with a dense reticulated *membrana propria*, surrounded by lymph spaces, around which are the capillary blood-vessels (fig. 665). The gland cells lining the alveoli fill nearly its whole cavity, and are, when at rest, full of granules which mask the nucleus. During secretory activity the granules diminish in number, becoming limited to the periphery of the cells, and the nucleus becomes distinct. From each acinus there passes a narrow intercalary duct, lined by a layer of flattened cells. These end in intralobular ducts, which are also narrow, lined by a layer of high columnar epithelial cells radially striated at base; these unite with interlobular ducts which have a layer of smooth muscle in their wall and a simple columnar epithelium, and, from the union of these, Stenson's duct originates. Each gland has in connection with it a threefold nervous mechanism, secretory filaments ending

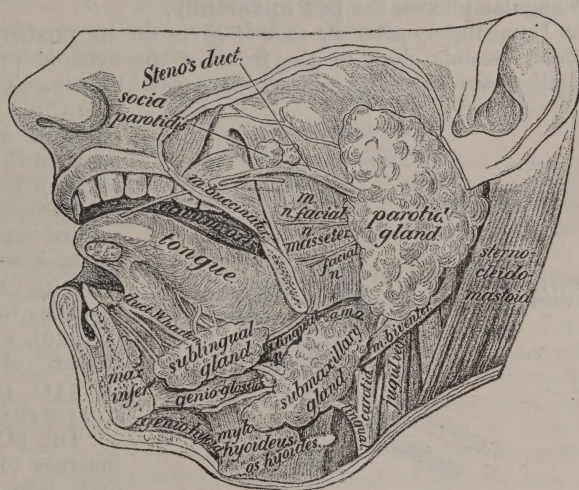


Fig. 655.—Dissection of the side of the face showing the salivary glands. A probe is passed through the opening of Stenson's duct.

beneath or in the glandular epithelium, afferent filaments passing to the salivary centre from the neighbouring mucosa, and vaso-dilator filaments to the vessels supplying it (fig. 656).

The parotid is largely influenced by motions of the lower jaw, which produce alternations of tension and pressure, favourable for its nutrition and capable of stimulating it to secretion. The parotid gland appears first as a solid cellular cord at the hinder angle of the fold between the mandible and the maxillary lobe, superficial to and above Meckel's cartilage. It rapidly grows backwards, lying at first over, then behind, the developing mandible and *masseter* muscle. Its deeper lobes do not become recognisable until the end of the first dentition. It first overlies the seventh nerve and vessels, but has begun to surround them at birth.

456. THE SECOND STAGE OF THE FACIAL NERVE (§ 537; fig. 613) is exposed by following backwards the branches which appear at the lower and front edge of the parotid, and by removing piecemeal the lobules of the gland which overlie it. The nerve is seen emerging from the stylo-mastoid foramen, and turning forwards to break up in the substance of the gland into a somewhat triangular plexus, the *pes anserinus*.

Immediately after its exit it gives off its **posterior auricular branch**, which ascends close to the front of the mastoid process and divides into a smaller *auricular*, and a larger or *occipital* branch. The auricular divides again into three, one of which enters the *retrahens aurem* (p. 527); a second supplies the *attollens aurem*, and receives a small branch of the auricularis magnus nerve (p. 541); and a third supplies the short muscles on the back of the auricle and the *antitragicus* (p. 524). The occipital branch ascends to the *occipitalis* muscle (p. 526), and communicates with a branch of the *occipitalis minor* (p. 541), sending a filament to the *transversus nuchæ*.

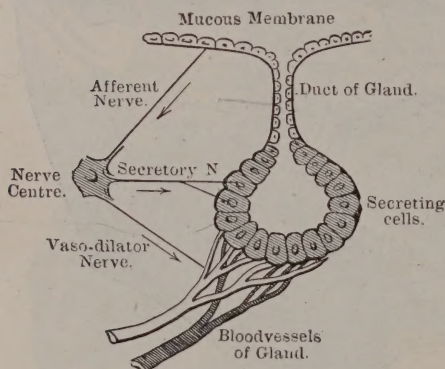


Fig. 656.—Scheme of the nervous mechanism of a salivary gland.

the long slender *stylo-hyoid* branch which enters the hinder surface of that muscle (p. 557) about the middle of its course; and (3) the *communicating* branch which crosses the jugular vein and joins the glosso-pharyngeal close to the ganglion of Andersch (§ 486), and is distributed, with fibres of the glosso-pharyngeal nerve, to the *stylo-pharyngeus* muscle (p. 602).

The facial trunk divides into two main terminal branches, the upper or **temporo-facial** is the larger, and as it passes upwards and forwards through the gland over the temporo-maxillary vein, it divides into three branches within the gland:—

1. The **temporal** ascends obliquely over the zygoma, sends two filaments backwards, one to the anterior muscles of the ear, and a second to the *attrahens aurem*. It receives a communicating branch from the auriculo-temporal nerve (p. 597), and then sends a third branch to the *frontalis* (fig. 614), and a fourth to the upper part of the *orbicularis palpebrarum* (*ib.*; p. 630). This communicates with the temporal branch of the superior maxillary and with a branch of the supraorbital, and the conjoint terminal filaments are distributed to the dermal muscles of the forehead and the overlying skin.

2. The **malar** branch passes forwards beneath the socia parotidis over the transverse facial artery (p. 564), and is distributed to the outer and lower

fibres of the *orbicularis palpebrarum* (§ 511) and the deeper fibres in the lids, as well as to the *zygomaticus* (fig. 614).

3. The **superior bucco-labial** nerve passes horizontally along Stenson's duct and between the two strata of facial muscles. It is distributed to the *buccinator* (p. 585), *levator labii superioris* (p. 536), the *levator anguli oris*, and the zygomatic slip of the *orbicularis*. It communicates extensively with the branches of the infraorbital nerve on the surface of the *levator anguli oris*, which it also supplies.

The **cervico-facial** branch is smaller, passes downwards and forwards, and is distributed to all the facial muscles below the level of the angle of the mouth. It divides in the parotid gland into two branches—(a) **inferior bucco-labial**, which crosses the *masseter* and is distributed to the mandibular part of the *buccinator*, *risorius*, *depressor anguli oris*, and *depressor labii inferioris* muscles (fig. 624); and (b) **cervical**, which descends below the angle of the jaw beneath the *platysma*, to which it is distributed. It forms under that muscle two loops, with sensory branches of the superficialis colli nerve (p. 542). All these branches may be more or less subdivided.

457. MUSCLES OF MASTICATION.—These are four on each side, the *masseter*, the *temporal*, and the two *pterygoids*.

Dissection.—Divide Stenson's duct as it emerges from the parotid, and reflect it forwards. Remove the structures which overlie the *masseter* muscle—viz., some fibres of the *platysma*, the socia and margin of the parotid gland, the bucco-labial branches of the facial nerve, and the transverse facial artery. Remove also the closely adherent sheath derived from the cervical fascia.

Masseter (*μάσητήρ*, *Hippocrates*) is a thick, quadrate, somewhat bilaminar muscle, whose superficial stratum arises chiefly by a flat tendon from the lower edge of the malar bone and the malar process of the maxilla. The fascicles of the tendon are irregularly prolonged into the thick, short fleshy belly, which descends backwards to be inserted into the outer surface of the lower half of the ramus of the jaw. The triangular, deeper stratum is imperfectly separable from, and uncovered by, the superficial part posteriorly, but is fused with it into a rounded border in front, and arises chiefly by fleshy fibres from the inner surface of the malar bone. Vertically descending, it is inserted into the ramus of the jaw, above the superficial part, as high as the sigmoid notch.

The *masseter* covers the mandibular ramus and its own vessels and nerves; its front edge overlaps the buccal fat and the *buccinator*. Sometimes a bursa or a space of loose connective tissue partially intervenes between its two layers, but this is uncommon. The fleshy fascicles of the two parts are equal in length, the difference being in the length of the tendinous fibres. The *masseter* elevates the lower jaw; each muscle, acting separately, has some slight influence in drawing the jaw to the opposite side. In the fetus, it is more oblique and less tendinous; it increases in length with the growth of the molar teeth.

Dissection.—The superficial auricular muscles (p. 527), temporal artery (p. 563), and auriculo-temporal nerve (p. 597) having been examined or reviewed are to be removed, and the surface of the temporal fascia to be cleaned from the loose tissue covering it, which is sometimes unnecessarily regarded as a separate layer.

458. THE TEMPORAL FASCIA is a strong fibrous sheet, single, thin, and semi-transparent above, where it is attached to the superior temporal crest on the temporal and parietal bones, continuous with the pericranium, and on a plane beneath the epicranial aponeurosis. Below and at its frontal attachment it becomes bilaminar and opaque, its two layers being separated by twigs of the temporal branches of the superior maxillary nerve and a lamina of fat, the layers being attached respectively to the outer and inner edges of the upper margins of the zygoma and malar bones.

The fascia consists of two lamellæ of decussating fibres; anteriorly, a strong series of ascending fibres pass from the marginal process of the malar to the upper part of the temporal ridge of the frontal.

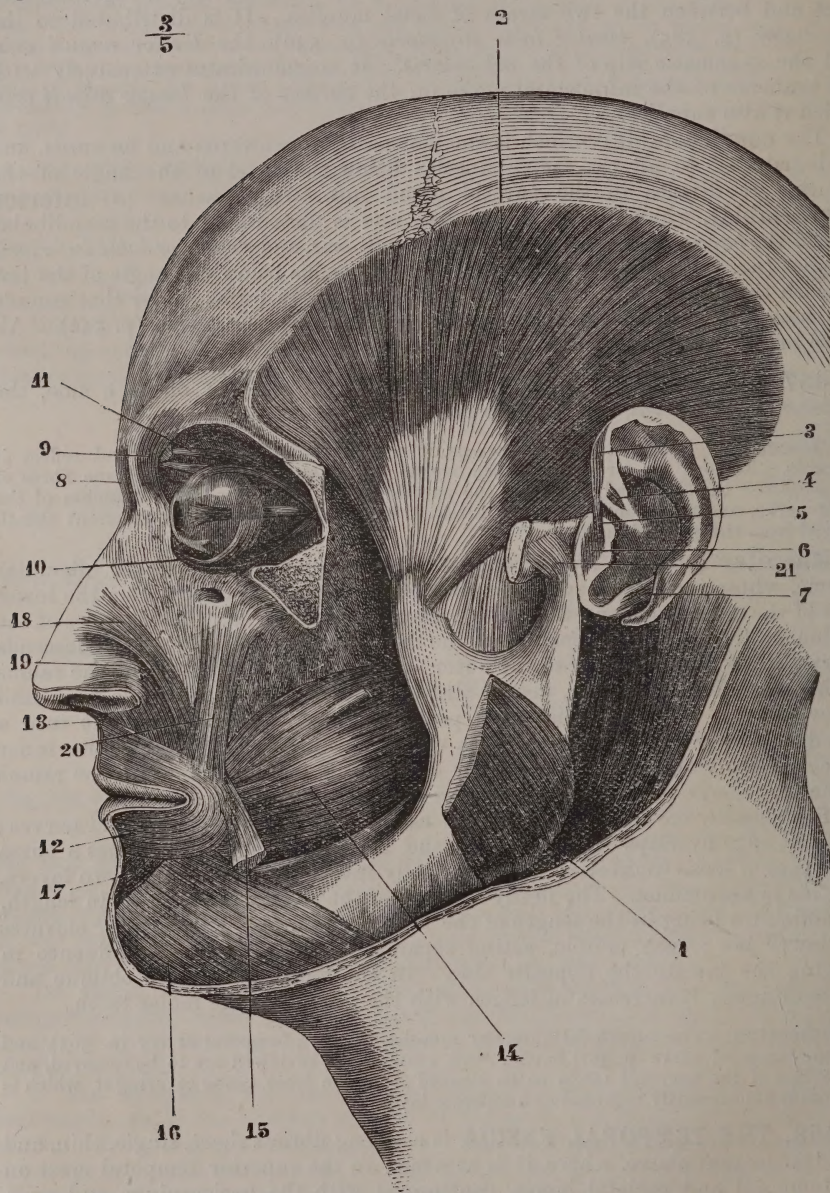


Fig. 657.—Muscles of mastication—1, masseter; 2, temporal; 3, helix major; 4, helix minor; 5, tragus major; 6, tragus minor; 7, antitragus; 8, pyramidalis nasi; 9, corrugator supercilii; 10, inferior oblique; 11, superior oblique; 12, orbicular fibres round the mouth, unnaturally drawn; 13, naso-labial fibres; 14, buccinator; 15, depressor anguli oris; 16, depressor labii inferioris; 17, levator menti, unnaturally drawn; 18, compressor nasi; 19, dilator alae nasi; 20, levator anguli oris; 21, capsule of lower jaw.

Dissection.—Divide the temporal fascia along the upper edge of the zygoma and remove it from the surface of the muscle, sparing the temporal branch of the maxillary nerve. Divide with the saw the zygoma in front and behind the attachment of the *masseter*, and reflect it downwards, leaving the *masseter* attached to it. Clean and trace the masseteric nerve and artery as they emerge through the sigmoid notch, close to the front of the condyle, and divide them as they enter the deep surface of the *masseter* muscle, and clean the surface of the *temporal* muscle. In front of its tendon the buccal nerve should be found and cleaned. In the small space behind the coronoid process and above the edge of the sigmoid notch, a small portion of the internal maxillary artery appears.

459. THE TEMPORAL MUSCLE (fig. 657, 2) is large, flat, and fan-shaped, occupying and arising from the bony wall of the temporal fossa, except at its anterior part where few or no fibres arise from the malar bone, from which the muscle is separated by a very soft mass of fat. A thin stratum of fleshy fibres arises from the deep surface of the fascia which covers it. The muscular fibres are short, averaging 4 cm., and soon end in a fan-shaped tendon, beginning on the surface of the main mass of the muscle, and only covered by the fibres which arise from the fascia. The hinder fibres pass forwards over the root of the zygoma; most of the fibres descend obliquely forwards, but the frontal fibres descend nearly vertically. On its deep surface its lowest fibres arise by a strong tendon attached to the crista infratemporalis on the sphenoid and squamosal bones. These fibres descend outwards at a very small angle. The insertion is by a strong tendon into the tip, front edge, and inner surface of the coronoid process of the lower jaw, extending nearly as far as the socket of the hindmost tooth.

The buccal nerve and artery descend close to the anterior border of the tendon, the masseteric nerve and artery behind it. The pre-temporal fat is soft and large-grained, and when absorbed causes the falling in of the skin of this region. Fat of the same character also underlies the temporal aponeurosis above the zygoma. The *temporal* and *masseter* are separated parts of one primary muscle, and preserve traces of their primitive connection in the form of irregular connecting fibres. The changes of position of the muscle in the open and closed condition of the mouth are to be noted. The student must remember that during life the condyle of the jaw is advanced on the articular eminence when the mouth is opened, hence the opening of the jaw by muscular action during life and by external force after death are not identical actions. The *temporal* is a triangular muscle, whose resultant is a line from the front edge of the coronoid process to a point a little behind the bregma. In action it therefore retracts the jaw.

Dissection.—Divide now the coronoid process of the lower jaw by an oblique section carried from the bottom of the sigmoid notch downwards and forwards to the front of the ramus, above the last molar tooth. Raise the coronoid process, and with it the whole *temporal* muscle upwards from the floor of the fossa. In so doing the upper part of a rather firm connective lamella, which passes from the inner side of this process inwards to the external pterygoid plate (the pterygo-mandibular ligament), must be divided. Close to the bone the anterior and posterior deep temporal nerves and arteries ascend beneath the muscle, and are to be preserved. The middle deep temporal branch of the superficial temporal can now be traced through the muscle to the surface of the temporal bone.

When the region behind the post-zygomatic part of the *temporal* muscle has thus been exposed, divide the neck of the lower jaw transversely and cut the ramus across transversely on the level of the mid-point between the angle and the condyle. It is most convenient to make these sections through two-thirds of the bone with a Hey's saw and to complete the division with the bone forceps. Remove the intervening piece of bone, taking care to leave uninjured the inferior dental nerve and vessels which enter the inferior dental canal in the lower jaw, opposite the level of the lower line of section. Carefully remove the fat which lies behind the jaw, and the internal maxillary artery, the terminal branch of the external carotid, is then exposed, as also are the lingual, inferior dental, and buccal nerves internal to it. The removal of the fat also brings into view the internal lateral ligament of the mandible, and the two *pterygoid* muscles.

460. EXTERNAL PTERYGOID, a short, thick, nearly horizontal muscle arises—(1) below, from the outer surface of the external pterygoid plate and the contiguous surface of the tuber maxillare below it, and (2) above, from the lower part of the infratemporal crest on the ali-sphenoid and from the zygomatic surface of the bone below it. This head is the weaker. The fibres converge

from these origins, to be inserted into the pterygoid fossa beneath the condyle of the mandible, some fibres of the upper head being inserted into the front of the capsular ligament over the lower synovial membrane and into the inter-articular fibro-cartilage.

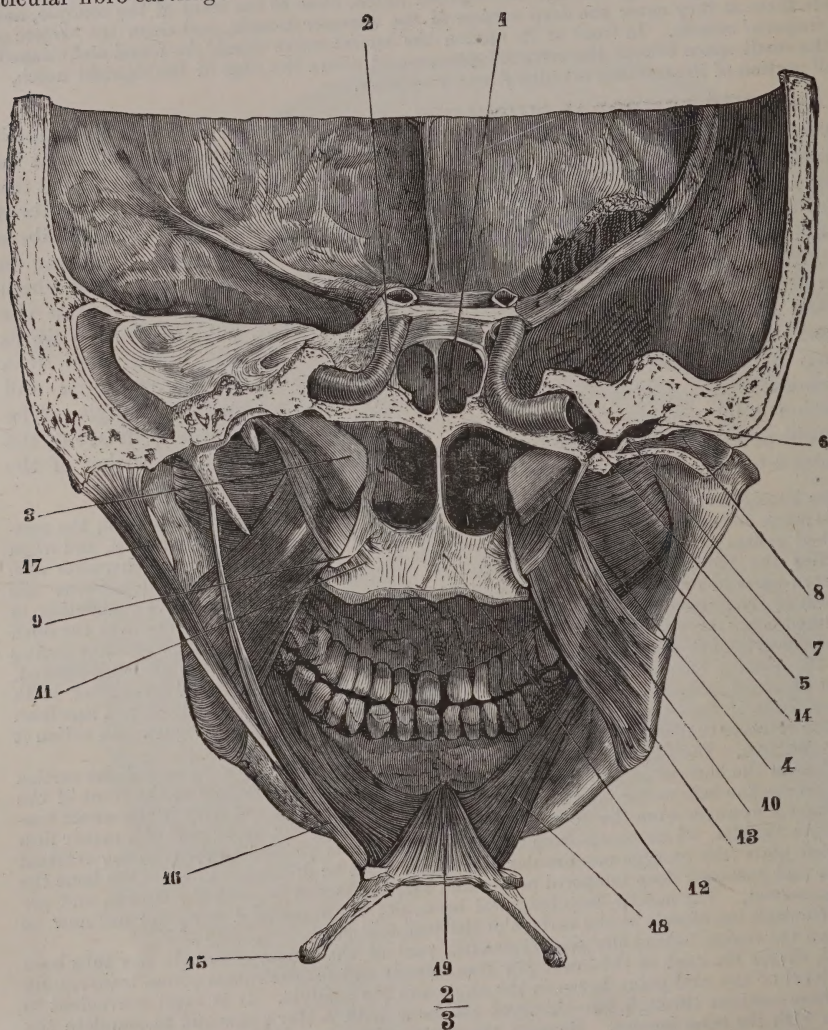


Fig. 658.—Coronal section of skull seen from behind, showing the pterygoid muscles—1, sphenoidal sinus; 2, third stage of internal carotid artery; 3, Eustachian tube; 4, its inferior edge opened; 5, its bony part; 6, tympanic cavity; 7, membrana tympani; 8, external auditory meatus; 9, hamular process; 10, 11, tensor palati; 12, palatine aponeurosis; 13, internal pterygoid; 14, external pterygoid; 15, hyoid bone, greater cornu; 16, stylo-hyoid muscle; 17, digastric; 18, mylo-hyoid; 19, genio-hyoid.

The interval between the two heads is filled by a large and complex pterygoid plexus of veins, the buccal nerve, and the internal maxillary artery.

The ridging and dishing of the external pterygoid plate is correlative with the strength of the muscle, as its origin is always intersected by tendinous planes.

for which there are rough lines on the surface of the bone. The deep surface of the *external pterygoid* rests on the *internal pterygoid*, the internal lateral ligament, the inferior dental and lingual nerves, and the middle meningeal artery. Above its upper border pass the masseteric and deep temporal nerves and vessels. The *external pterygoid* muscle can advance the whole jaw, and thus it opens the mouth. When they act alternately they can make the teeth grind upon each other. The external pterygoid nerve from the inferior maxillary enters the muscle on its inner surface.

461. THE INTERNAL PTERYGOID MUSCLE is a thick mass on the inner side of the ramus of the jaw, closely resembling the *masseter* on the outside. It arises from the inner surface of the external pterygoid plate, thus filling up much of the pterygoid fossa, and from the outer surface of the tuberosity of the palatine bone, and the contiguous knob of the maxilla. Its fibres pass downwards, a little backwards and outwards, expanding, and are inserted into the rough impression on the inner side of the angle of the mandible, tendinous planes traversing the fleshy fibres and being attached to the rough, bony ridges on this area. It bears on its antero-external surface the inferior dental vessels and nerve, the internal lateral ligament, and the lingual nerve, and lies upon

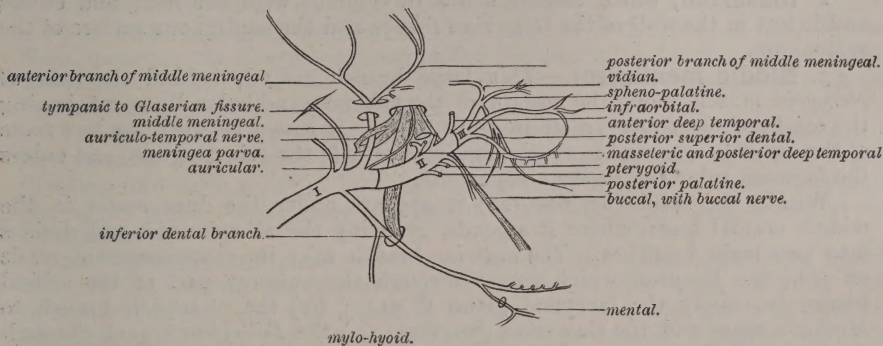


Fig. 659.—Scheme of the internal maxillary artery—I., II., III., its three stages.

the *superior constrictor* of the pharynx and the *tensor palati* muscle. The facial artery also touches its deep surface as it loops behind the body of the jaw.

This muscle acts with the *masseter* in raising the jaw; its nerve from the inferior maxillary enters its posterior surface.

462. THE INTERNAL MAXILLARY ARTERY (fig. 659) is, in general, now exposed, and, when this is the case, its course may, for convenience, be divided into three stages:—

1. From its origin it passes horizontally forwards and inwards behind the neck of the lower jaw, and enters the triangular space bounded by the *external pterygoid* muscle above, the *internal pterygoid* below, and by the ramus of the lower jaw externally. It separates the neck of the jaw from the spheno-mandibular ligament, which lies internal to it. Internal and below it are the inferior dental and lingual nerves.

2. Having passed below the *external pterygoid*, it turns upwards on the anterior and outer surface of that muscle under cover of the lower part of the *temporal* muscle, and closely surrounded by the pterygoid plexus of veins.

3. The artery then turns inwards between the two heads of the *external pterygoid*, and ends in the pterygo-maxillary fossa by breaking up into its terminal branches. The course of this vessel is always tortuous in the adult.

In 40 per cent. of cases the course of the artery is different; having passed

between the neck of the lower jaw and the internal lateral ligament, the artery passes *behind* the lower head of the *external pterygoid* muscle, and does not appear in the dissection until it reaches the interval between the two heads of that muscle where it projects as a loop. This is the commonest arrangement of the artery in mammals; when it occurs, the artery sends in its first stage a muscular branch over the *external pterygoid*, which takes the ordinary course of the above described second stage; this gives off the masseteric and temporal branches, and by a small pterygoid anastomotic branch communicates between the heads of the *external pterygoid* with the loop of the trunk artery. This seems to be the primitive course of the artery, and the first described adult or commonest condition, which is correlated with the increasing development of the *pterygoid* muscles in man, and the consequent obliteration by pressure of the main channel after it has given off the middle meningeal branch, has arisen by the dilatation of that pterygoid anastomosis.

The branches given off from the artery in the first stage are:—

1. **Deep auricular.**—This passes upwards behind the capsule of the joint of the lower jaw, to which it may send branches; but it is chiefly distributed to the outer auditory meatus and the membrana tympani, in which it terminates by anastomosing by a series of radiating vessels with the other tympanic arteries.

2. **Glaserian,** which usually arises in common with the next, and enters and is lost in the wall of the Glaserian fissure and the contiguous surface of the tympanum.

3. **Middle meningeal.**—This large branch ascends behind the *external pterygoid* muscle along the margin of the speno-mandibular ligament, having the origin of the *tensor palati* in front of it. It passes between the two roots of the auriculo-temporal nerve, behind and outside the otic ganglion, and enters the foramen spinosum in the ali-sphenoid.

Within the skull (fig. 66o, 26) it appears under the dura mater in the middle cranial fossa, where it ascends, grooving the ali-sphenoid, and divides into two main branches. The *anterior* branch near its commencement sends off—(a.) the *lacrymal* which passes through the outmost part of the orbital fissure to supply the lacrymal gland (§ 512); (b.) the *Gasserian* branch to Meckel's space and the Gasserian ganglion; (c.) the *Fallopian* branch through the hiatus Fallopii to supply the facial nerve; and (d.) the *tympanic* which runs in the canal for the *tensor tympani* and supplies that muscle and the mucous membrane about its tendon. Minute irregular nutrient branches pierce the sphenoid and communicate with the periosteal branches of the deep temporal arteries externally.

The *anterior terminal* branch grooves the upper part of the ali-sphenoid, the anterior inferior angle of the parietal, in which it may be included in a canal, and its divisions stream upwards and backwards, branching on the inside of that bone which it supplies.

The posterior terminal branch is smaller, and its branches groove the squamosal and the hinder part of the parietal bone.

4. The **small meningeal**, often a branch of the last, ascends through the foramen ovale beneath the inferior maxillary nerve and supplies the dura mater about Meckel's space.

5. **Inferior dental** passes downwards from the parent artery as it lies on the speno-mandibular ligament behind and external to the inferior dental nerve with which it enters the dental canal in the mandible. It gives off near its origin a *comes nervi lingualis* which accompanies that nerve (p. 599), and is lost in the mucous membrane of the mouth. As it enters the dental canal it gives a *mylo-hyoid branch* which accompanies the nerve of that name to the submaxillary region to end in the mylo-hyoid muscle (p. 586), anastomosing with the submental.

Within the canal it sends *dental* branches through the fundus of each alveolus into the pulp tubes of each tooth, and opposite the first molar it sends off a large *mental* branch which escapes by the mental foramen to be distributed to the skin and muscles of the chin and lower lip, anastomosing with branches of the facial artery.

6. As the first stage is merging into the second a **muscular** branch comes off from the internal maxillary, which at once divides into *masseteric* and *posterior deep temporal* branches.

The masseteric has been already seen passing through the sigmoid notch, behind the temporal tendon into the deep surface of its muscle. The posterior deep temporal ascends at first between the *temporal* and *external pterygoid* muscles, and then lies close to the bones beneath the muscle which it supplies.

7. The **buccal** artery is small and tortuous, accompanies the buccal nerve (p. 600), to end in the *buccinator* muscle and mucous membrane of the cheek, anastomosing with the buccal branches of the facial, transverse facial, and infraorbital arteries.

8. The **external pterygoid branches** are usually several and very small.

9. The **internal pterygoid branch**, likewise small and numerous.

As the artery enters its third stage it gives off—

10. **Anterior deep temporal** which ascends in the front of the temporal fossa, grooving the ali-sphenoid, supplying the muscle, and giving off zygomatic branches through the orbital canal in the malar bone, to anastomose with the lacrymal and transverse facial arteries.

11. **Superior alveolar** descends tortuously outward on the tuber maxillare, sending off branches into the antrum, through several holes, and finally dividing into three series of branches—*dental*, which pierce the bone to supply the upper molar teeth; *gingival*, distributed to the gums; and *buccal*, to the buccinator.

12. **Infraorbital** passes in a loop towards the speno-maxillary fissure beneath the *orbitalis* muscle, and enters the infraorbital canal, where it runs in the floor of the orbit with its nerve (§ 532). Having sent one or two orbital branches to the fat and lowest muscles, and one *anterior superior dental* to supply the incisor and canine teeth, it escapes through the infraorbital foramen, and breaks up into branches in the face below the *levator labii superioris*, supplying blood to the surrounding parts; one series of small branches perforating the holes of the sutura notha (p. 235) to supply the anterior region of the nose.

The three terminal branches—**Vidian, speno-palatine, and superior palatine**—all enter definite bony canals, and accompany their nerves (§ 533).

13. The *Vidian* artery is very small, and ends in the cartilage of the anterior lacerate hole by joining with branches of the pharyngea ascendens and stylo-mastoid arteries.

14. The *superior palatine*, much larger, descends in the posterior palatine canal, wherein it gives off two accessory palatine branches to the soft palate and tonsil, and finally is distributed to the hard palate, anastomosing laterally with the gingival branches of the alveolar, above with the speno-palatine, and in front with the deep branches of the facial (p. 596).

15. The *spheno-palatine* or terminal branch of the internal maxillary enters the nose by the speno-palatine foramen, and gives off at once a *pterygo-pharyngeal* branch, which passes backwards through the pterygo-pharyngeal canal to the basilar region of the pharynx. It then gives off—(1) a *descending pharyngeal*, which arises not far from the pterygo-pharyngeal, and is distributed to the roof of the pharynx and to the pharyngeal recesses; (2) the *posterior nasal* branches which supply the mucous membrane of the upper and back parts of the nose

and ethmoidal cells; and (3) the *naso-palatine* artery, which passes along the roof of the nose to the septum, on which it divides into *superior* and *inferior* branches. The former sends branches to and through the cribriform plate of the ethmoid; the latter descends obliquely on the septum towards the anterior palatine foramen, where it supplies the septum, and anastomoses through the canal of Stenson with the palatine arteries (p. 583).

These branches cannot be seen at present, but will be followed in the subsequent dissections, to which references are given.

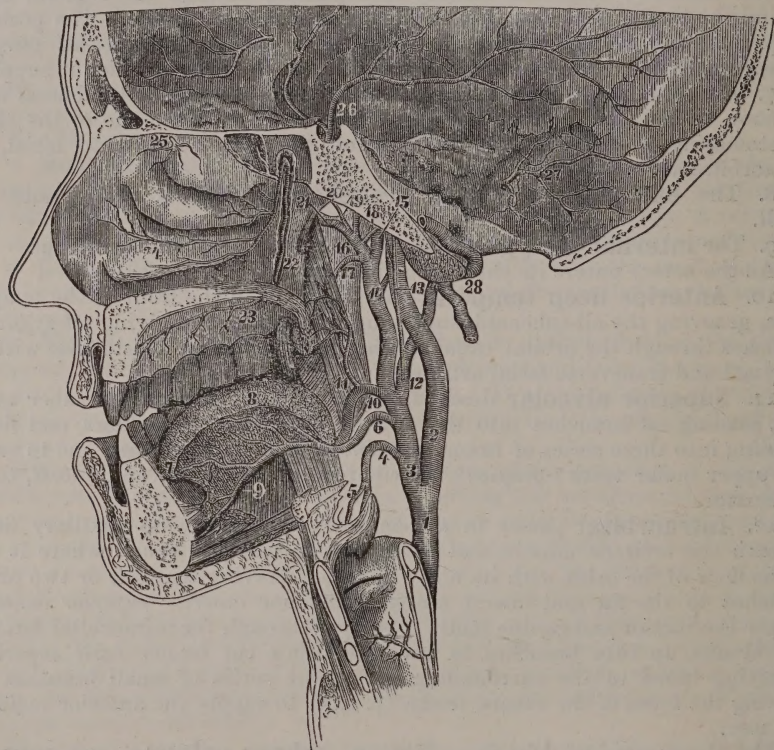


Fig. 660.—The deep arteries of the head, seen from within, in a medial section of the head and neck.—1, common carotid; 2, internal carotid; 3, external carotid; 4, superior thyroid; 5, superior laryngeal; 6, lingual; 7, ranine artery at tip of tongue; 8, dorsalis linguae; 9, sublingual; 10, facial; 11, ascending palatine; 12, occipital; 13, ascending pharyngeal; 14, posterior auris; 15, temporal; 16, internal maxillary; 17, inferior dental; 18, tympanic; 19, 26, middle meningeal; 20, meningea parva; 21, third stage of internal maxillary; 22, 23, superior palatine artery; 24, sphenopalatine; 25, anterior ethmoidal; 27, mastoid; 28, vertebral.

463. THE VEINS accompanying the branches of the internal maxillary artery unite in a large close-meshed pterygoid plexus around the *external pterygoid* muscle. The chief stems forming this plexus are—(1) the sphenomaxillary, three frequently-uniting veins from the nasal fossæ; (2) the infra-orbital, a single vein; (3) the two middle meningeal veins from the foramen spinosum; (4) the Vesalian vein, which pierces the sphenoid and communicates with the cavernous sinus; (5) the communicating ophthalmic vein, which escapes from the orbit through the sphenomaxillary fissure; (6) the numerous muscular branches from the *temporal*, *masseter*, and *pterygoid* muscles.

The blood of the pterygoid plexus is conveyed away by two sets of channels, one a communicating branch with the facial vein, which passes with the buccal artery over the *external pterygoid* and *buccinator* muscles, the others are the two internal maxillary veins which accompany the artery behind the neck of the lower jaw to join the temporal vein and form with it the temporo-maxillary. There are no valves in any of the veins of the pterygoid plexus.

Dissection.—Remove the large-lobed mass of fat which lies under the edge of the masseter, following to their endings the branches of the buccal and facial nerve that cross it, and thereby expose the buccinator muscle.

464. THE BUCCINATOR (figs. 641, 657) makes a large part of the lateral wall of the vestibulum oris; it arises from the outer surfaces of the bases of the alveoli of the two hinder molar teeth in both upper and lower jaws, and from the pterygo-mandibular ligament which intervenes between the jaws, and which has been already partially seen (p. 579), and which in life may be felt by passing the finger internal to the coronoid process of the lower jaw. The fibres pass forwards in the substance of the cheek to the angle of the mouth where they decussate as has been described (p. 537).

On its surface lie the facial vein and artery, the branches of the facial and buccal nerves and artery, and the buccal mass of fat. It is supplied by the facial nerve, and pierced by the buccal (sensory) branch of the inferior maxillary nerve, which is distributed to the mucosa beneath it.

465. THE CAVITY OF THE MOUTH (*cavum oris*) is the space bounded above by the hard palate, in front and laterally by the teeth and gums, behind by the soft palate, its arches and the opening bounded by them into the pharynx (*isthmus faucium*), and below by the tongue and the sublingual floor. The space is lined by mucosa, continuous behind the last molar tooth, and by the interdental bridges of gum, with that of the vestibule. It is only a slit-like cavity when the mouth is closed. Its cavity can be seen from the opened vestibule by depressing the lower jaw.

The bounding surface consists of four areas, (1) the sublingual floor, (2) the tongue, (3) the hard palate, and (4) the soft palate and its arches.

466. THE SUBLINGUAL FLOOR consists of the parts on each side and in front of the tongue included within the horseshoe of the lower jaw. Its mucous surface, shown by raising and pushing backwards the tongue, presents several noteworthy appearances. In the middle line there is a mucous fold, the *frænum linguæ*, reflected from the floor on the under side of the tongue. This is sometimes continued farther forward than usual, in which case the tongue is said to be tied and the speech is lisping, a condition easily remedied by snipping its free border with a blunt-pointed pair of scissors. Below and on each side is a rough, uneven *sublingual fold*, converging to its fellow in front, and pierced by the ducts of the sublingual gland. At its anterior and outer part on each side of the *frænum* is a distinct firm tubercle, the *papilla submaxillaris*, upon which the submaxillary duct opens.

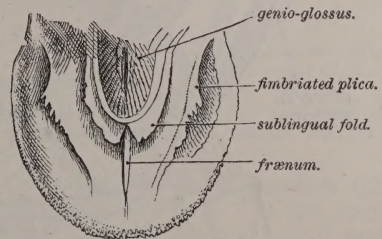


Fig. 661.—Folds of mucous membrane under the foetal tongue.

On the under surface of the foetal tongue are two thin and fringed ridges, the *pliae fimbriatæ*, homologues of the soft nonmuscular under-tongue of the lemurs. These become obscure or else they completely disappear in the adult.

The dissection of the deeper structures in the floor of the mouth should be made from below. Accordingly, the head being forcibly drawn backwards and a little to the opposite side and the larynx downwards, the parts beneath the chin are in a position to be dissected.

Already the anterior belly of the *digastric* has been shown by the removal of the skin, *platysma*, and fascia which covered it (p. 556). This muscle should be reviewed, its nerve (a branch of the mylo-hyoid division of the inferior maxillary) cleaned and divided, and it should then be reflected from its mandibular attachment. The submaxillary gland which lies external to it should be gently raised from its bed and drawn backwards, together with the facial artery and thereby the surface of the subjacent muscle is shown.

467. MYLO-HYOID (fig. 658, 18), a thin, flat, three-edged muscle, uniting in a median raphé with its fellow and so forming a floor for this region, arises by short, tendinous fibres from the mylo-hyoid ridge on the mandible, extending from the level of the last molar nearly to the side of the symphysis. Its fibres descend inwards to the median raphé, its hinder fibres being inserted into the body of the hyoid bone.

The lower surface of this muscle is covered by the *digastric* and its nerve, the inside of the mandibular ramus and the submental artery, the submaxillary gland, fascia, and skin. Its nerve of supply, from the inferior maxillary, enters it superficially. Around its free hinder border a part of the submaxillary gland passes to get under cover of the muscle.

Detach the *mylo-hyoid* from the mandible, and from the median raphé, and reflect it backwards and inwards towards its hyoid attachment. The parts exposed beneath it are the *stylo-glossus*, *genio-hyoid*, *genio-glossus*, and *hyo-glossus* muscles, the lingual branch of the fifth nerve, the hypoglossal nerve, the sublingual plexus of veins, submaxillary duct, sublingual gland, and the mucous membrane.

The *mylo-hyoid* and anterior belly of the *digastric* are separated portions of the median mandibular muscle, and, with the *temporal*, *pterygoid*, and *masseter*, make up the fifth-pair system of muscles.

468. GENIO-HYOID (figs. 658, 19 ; 662), on each side of the median line immediately under cover of the *mylo-hyoid*, arises by a narrow tendinous origin from the inferior genial tubercle on the mandible. The two muscles run parallel, and are contiguous, separated by a narrow median plane of areolar tissue ;

they are inserted into the upper and anterior facets on each side of the body of the hyoid bone. Its nerve, which enters it externally from the hypoglossal, is derived from the cervical contingent of fibres which that nerve has received from the first cervical (fig. 627, *ge*). Its blood supply comes from the submental artery.

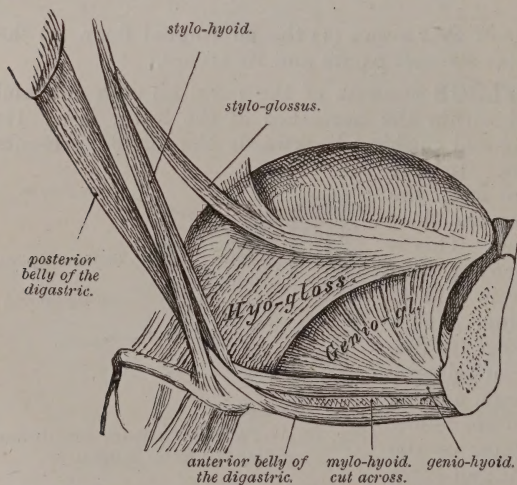


Fig. 662.—Muscles of the side of the tongue.

This is a portion of the same medio-ventral muscular mass as that of which the infrahyoid muscles are segmentations, and with which it is associated by its innervation (p. 544).

The deeper muscles which form the rest of the floor of the mouth belong to a separate system, being supplied by the hypoglossal nerve.

469. STYLO-GLOSSUS is a thin skew band of muscle arising from the styloid process near its tip, and from the adjoining part of the stylo-mandibular ligament. As it descends forwards it expands and turns on itself, dividing at the outer side of the tongue into two slips, an upper, smaller, which passes internal to the *palato-glossus* muscle and whose fibres enter the tongue nearly

transversely and near its dorsal surface, mixing up with the other fibres therein, and a lower, larger band which passes forwards on the surface of the *hyo-glossus*, and to some extent interlacing with its fascicles towards the tip of the tongue. *Stylo-glossus* can retract the tongue and raise its sides, making it transversely concave above.

470. HYO-GLOSSUS (fig. 662), thin and square, arises from the side of the basi-hyal bone and the thyro-hyal cornu, and sometimes from the cerato-hyal. Its fibres ascend for the most part parallel to each other, the anterior diverging a little forwards, and they are inserted into the side of the tongue, where they interlace with the other fibres of that organ, especially with those of the last and the *palato-glossus* muscles. Upon its surface the hypoglossal nerve, the sub-

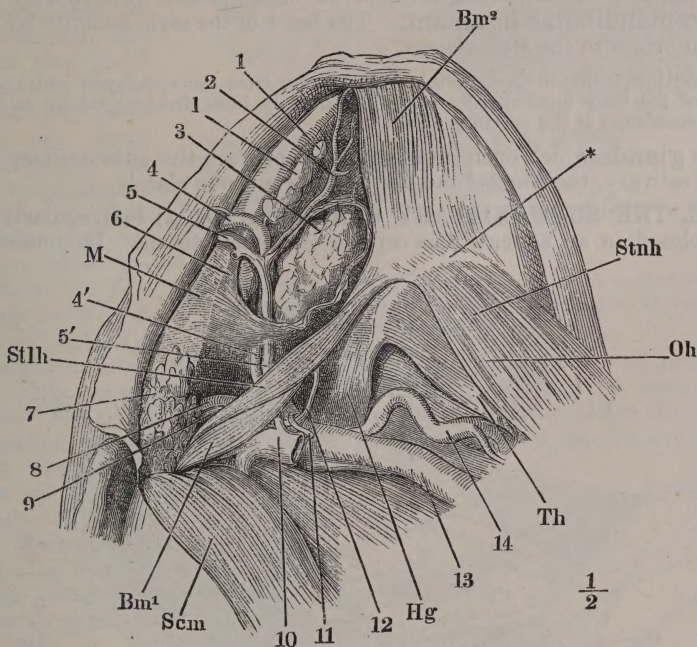


Fig. 663.—Superficial dissection of the submaxillary space from below—Bm¹, posterior belly of digastric; Bm², anterior belly; *, basihyal; 1, sublingual gland; 2, submental artery; 3, submaxillary gland; 4, facial artery; 5, facial vein; 6, stylo-maxillary ligament; 7, parotid gland; 8, external carotid artery; 9, temporo-maxillary vein; 10, common jugular vein; 11, sterno-mastoid artery; 12, hypoglossal nerve; 13, common carotid; 14, superior thyroid.

maxillary duct, and the lingual nerve pass forwards, and at its insertion the mucous membrane of the mouth and sublingual gland overlies it. It lies upon the middle constrictor of the pharynx, the *genio-glossus*, the lingual artery, and the stylo-hyoid ligament.

Occasionally, but not often, the slip from the cerato-hyal is distinct and overlies the *stylo-glossus*. This is then called *chondro-glossus*. Still more rarely there is a separate slip from the corpus triticeum (*triticeo-glossus*) or from the thyro-hyal cornu. This muscle retracts the tongue and renders its dorsum convex upwards.

471. THE STYLO-HYOID LIGAMENT begins near the tip of the styloid process as a fine cartilaginous filament enveloped in a fibrous sheath. The cartilage usually ceases after a short course, and the fibrous cord is continued behind the *stylo-glossus*, in front of *stylo-pharyngeus*, across the sheath of the internal carotid artery, to pass under the hinder edge of the *hyo-glossus*. Here

again a little cartilage usually reappears, and it is attached to the tip of the lesser cornu of the hyoid bone.

It is the rudimentary epihyal, and is variable in its degree of development. The *middle constrictor* takes origin from its hinder surface.

Quite different in its nature and relations is the **stylo-mandibular ligament**, which can also be seen in the present dissection. It is a process of the cervical fascia dipping from the mandibular angle to the outer side of the styloid process, and it separates the parotid gland behind from the submaxillary gland in front. Its inferior border is lost in the cervical fascia over the hinder edge of the submaxillary gland; above, it sheathes the upper surface of the internal pterygoid, and is continuous through an intermediate thin lamella with the **spheno-mandibular ligament**. The front of the stylo-mandibular ligament gives an origin to the *stylo-glossus*.

Dissection.—Divide the mandible 1 centimetre from the symphysis and turn the cut portion of the body upwards (the ramus has already been divided), taking care that the mucous membrane of the mouth is uncut.

The **glands** which open into the cavum oris are the *submaxillary* and *sublingual* salivary, the *lingual* and the *palatine* mucous glands.

472. THE SUBMAXILLARY GLAND (fig. 663, 3) is irregularly rounded and enclosed in an adventitious capsule of areolar tissue. It consists of two

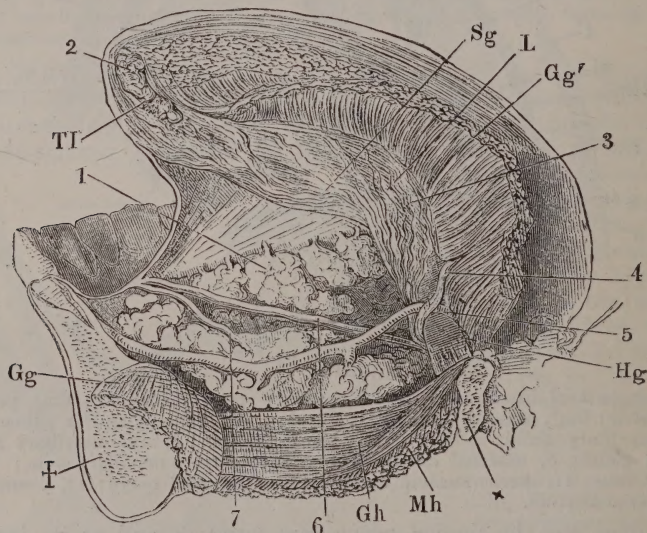


Fig. 664.—Dissection of the sublingual gland (1)—2, apical gland of Nuhn; 3, lingual nerve; 4, hypoglossal nerve; 5, sublingual artery; 6, Wharton's duct; 7, duct of Bartholin; Gg, genio-glossus; Sg, stylo-glossus; L, lingualis; Hg, hyo-glossus.

parts, an oval *superficial lobe*, which lies in the space between the body of the jaw, the anterior belly of the *digastric* and the stylo-maxillary ligament, over the *mylo-hyoid*, and the long, narrow, *deeper lobe* which passes behind and above the *mylo-hyoid* and lies under the mucous membrane, on the *hyo-glossus*. The jaw bone is smooth and concave where it overlies it, and the gland is covered only by skin, *platysma*, fascia, the facial vein, and a plexus of lymphatics with several glands. The facial artery lies in a deep groove in the gland, and gives off branches to it, and there are five small glands receiving the superficial facial lymphatics embedded in it or lying upon it. The duct begins in the centre of

this mass, and passes with the deep lobe round the hinder edge of the *mylo-hyoid* muscle to appear on the *hyo-glossus*. This tube (*the duct of Wharton*) is about 5 cm. long, and when flattened about 2 mm. broad, with coats 0.2 mm. thick. It lies at first between the lingual and the hypoglossal nerves, but rises above the lingual to its termination, which is by a narrow orifice 0.3 mm. diameter on the papilla submaxillaris. The volume of the gland is 7 cc., its weight about 8 grms.

473. THE SUBLINGUAL GLAND is also connected with the Whartonian duct. The lobules of this gland taken together make a long, narrow, ovate mass, 35 mm. long, directly beneath the mucous membrane of the sublingual plica. The anterior end lies close to its fellow on either side of the *frænum linguae* and a little in front of it. Its

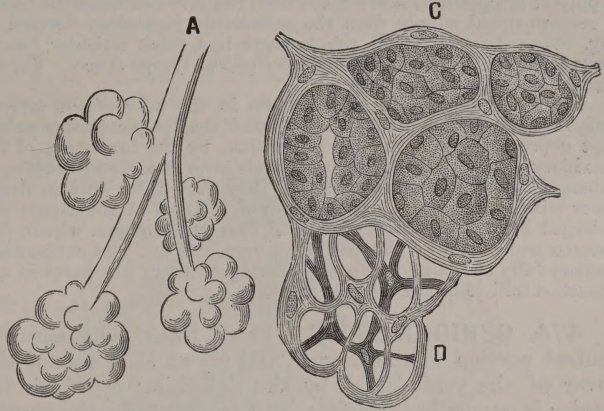


Fig. 665.—Structure of submaxillary gland—A, coarsely injected, showing acini; C, gland follicles, with nuclei; D, basket-like structure of basement membrane.

outer margin touches the smooth sublingual area of the lower jaw, while its inner edge extends as far as the *genio-glossus*, and below it rests on the *mylo-hyoid*. The hinder and outer part forms one fairly large lobe, the anterior part is broken up into a cluster of six to eight detached lobules, each with a separate duct.

The duct of the hinder lobe (*the duct of Rivini*, described also by Bartholin) runs parallel with the terminal part of Wharton's duct, and ends with it on the submaxillary tubercle; it is generally about 20 mm. long and 1 mm. in diameter.

Like Wharton's duct it has no muscular coat, but consists of a strong elastic tunica propria, a firm base-

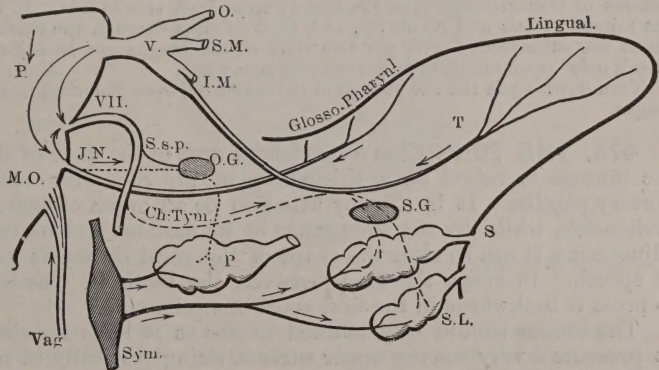


Fig. 666.—Innervation of the three salivary glands, diagrammatically shown—V., fifth nerve; O, ophthalmic nerve; S.M., superior maxillary; I.M., inferior maxillary; T, tongue; S., submaxillary gland; S.L., sublingual gland; S.G., submaxillary ganglion; O.G., otic ganglion; P., parotid gland; S.s.p., small superficial petrosal nerve; J.N., Jacobson's nerve; M.O., medulla oblongata.

ment layer and a single layer of columnar epithelium. The six or eight anterior ducts (**ducts of Walther**) open separately in a sinuous line on the sublingual plica. The innermost one, very seldom a second, opens into Wharton's duct. Collectively the volume of the gland is about 2.5 cc., the weight about 3 grammes.

The sublingual is a mucous gland, the submaxillary is mixed, some of the acini being aquiparous like those of the parotid, while others are muciparous and contain two sets of cells, large mucigenous cells each with a flat nucleus near the cell foot, staining imperfectly with carmine, and densely clustered smaller cells with oval nuclei lying on the basement and constituting the lunula of Gianuzzi (fig. 46). Aquiparous and muciparous follicles are arranged side by side, but the former are somewhat in excess. Each gland receives an abundant supply of sympathetic nerve fibres from the plexus around the facial artery, and, in addition, a cerebro-spinal supply from the submaxillary ganglion derived from the *chorda tympani* (fig. 666). In each gland acinus there is a thick reticular basement membrane as in the parotid (fig. 665), surrounded by a peripheral lymph space. The sublingual saliva is sticky, rich in mucus and corpuscles.

These salivary glands arise as pits in the floor of the lateral sulci which isolate the tongue. The furrow immediately around the tongue (*sulcus submaxillaris*) becomes at one spot depressed into a tubular pit, which, by the branching of its fundus, forms the submaxillary gland. The sublingual glands arise in a second (*sublingual*) sulcus external to the submaxillary by the same process. They thus differ only in degree, not in kind, from the other mixed mucous and serous glands of the floor of the *cavum oris*. These having become enlarged have also become condensed into solid masses, which, for convenience of packing, became embedded in the parietal musculature. The submaxillary like the parotid has become fully specialised. In the sublingual there are parts in all stages, from the single-branched follicle to the complex mass.

474. GENIO-GLOSSUS.—These thick, fan-shaped muscles make up the central portion of the tongue, and lie on each side of the middle plane, under cover of the *genio-hyoid*, by the detaching of which from the jaw its lower border is exposed. It arises by a tendon from the superior genial eminence of the mandible, and from this point its fibres radiate, the lowest passing into the basihyal above the *genio-hyoid*; the second series extend into the glosso-epiglottic frænum, and the main mass of the fibres lie in the middle of the tongue, the foremost passing forwards to its tip (fig. 662).

By detaching the origin of one *genio-glossus* at a later stage of the dissection, and separating it from its neighbour, the connective *septum linguæ* is brought into view. This consists of a median *raphé* of fibrillar and areolar tissue, in which central tendinous intersections of transverse fibres of the tongue cross from side to side. It is traversed by none but minute vessels and no nerves, and, as it extends through the thickness of the organ as far as the submucous layer, the two sides of the tongue can be injected separately, their vessels only communicating in the mucous membrane.

Turn down again the cut portion of the mandible, open the mouth, and draw forwards the tongue.

475. THE TONGUE is a specialised area of the floor of the mouth wherein the mucosa is raised on a thickening of the muscular wall and beset with sensory papillæ. It is thereby fitted to be an organ of taste, of touch, and of prehension, while, by the wide range of its motions and its capacity of delicate adjustment, it can so alter the shape of the vocal cavity as to act as an organ of speech. It keeps the food between the teeth in mastication, and serves to press it backwards in the first stage of swallowing.

The tongue should be examined *in situ* as it loses its shape when cut out. It presents a very convex upper surface, rising vertically in front of the top of the larynx, culminating opposite the molar teeth, from whence it slopes a little downwards and forwards. This *dorsal surface* is directed towards the soft and hard palate, and when the mouth is closed it rises nearly thereto. Its sides are parallel with and close to the arches of the teeth. The tongue consists of a body, a base placed behind and below, and a free tip in front.

The mucous membrane covering the tongue is reflected in front on the sublingual floor; here it presents certain *plicæ* which have been already described; laterally it is reflected on the inner side of the inferior alveolar arch. At the isthmus faucium it rises laterally in a sharp fold, the **anterior pillar of the fauces**, behind which it is reflected upwards on the **tonsil**. Still farther backwards are three folds from the tongue to the epiglottis, one sharp posterior

median, the **frænum epiglottidis**, and one blunter on each side, the lateral **glosso-epiglottic fold**. Between these on each side of the frænum is the **glosso-epiglottic fossa**. In volume the tongue is about 70 cm., and contains under the mucous covering about a quarter of a million muscular fibres, which, were they placed side by side, would form a muscle capable of raising a weight of 100 kilogrammes. The surface of the mucous membrane of the tongue is covered with a thick layer of stratified epithelium, which is constantly being shed and renewed; when the process of growth is increased, or when separation is delayed, these accumulate in the form of a coating on the tongue. Such a coating is supplemented by fragments of food and the growth of fungi, *Leptothrix*, *Oidium*, or *Torula*, and varies in colour according to the nature of these, or

to the presence of blood or other pigment, hence the appearance of the surface of the tongue is important as an evidence of the state of the digestive canal. On the dorsum of the tongue there is a slight depressed median **raphé**, which ends at the level of the isthmus faucium in a small pit, the **foramen cæcum**; from this two faint lateral grooves pass outwards towards the points of the anterior pillars of the fauces. In front of this V-like line the mucous membrane is thickly beset with papillæ of two kinds; the most abundant of these are **filiform papillæ**, which are somewhat conoidal processes of the mucosa, each divided at its summit into a cluster of recurved, hair-like processes covered, like the rest of the papillæ, by stratified scaly epithelium. These papillæ are

arranged in irregular lines diverging forwards from the raphé, but becoming nearly transverse towards the tip. They cover the dorsum of the tongue and become larger and longer towards the upper half of each lateral border, where they appear in longitudinal rows, and below this they disappear. There are about 500 of these in a sq. cm., and they are from .4 to 2 mm. in length.

These filiform papillæ are mainly prehensile, they roughen the surface of the papilla, and contain a tuft of vessels and a double-contoured nerve fibre in their corium. Many of them are simple or little branched, and are then called **conical papillæ**.

Fungiform Papillæ.—Scattered among the filiform papillæ are others of a different form. These are rounded and thicker, not covered by hair-like processes. They are usually bright red in colour, and taper slightly to their point of attachment. It is the projection of these bright papillæ through the white

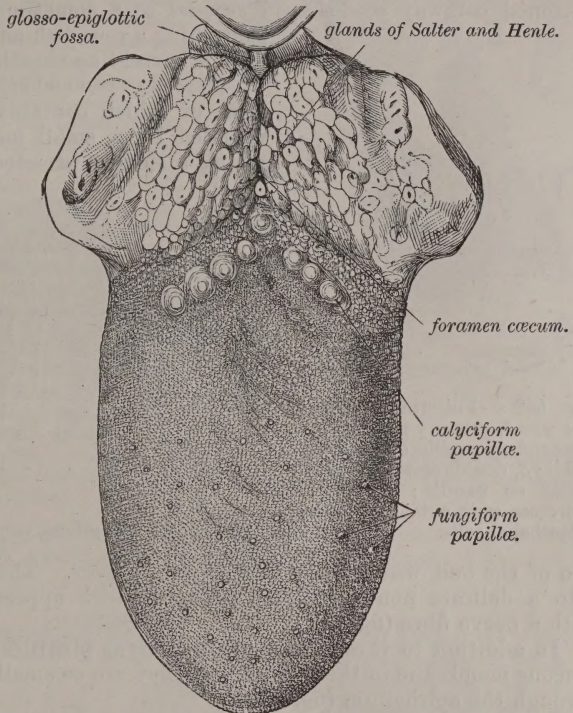


Fig. 667.—Upper surface of tongue when taken out and laid flat on the table.

fur-coating of the rest of the tongue in scarlatina before desquamation that gives its surface the characteristic "strawberry and cream" appearance. Each fungiform papilla is beset with minute conical papillulæ, but its epithelium is nearly uniform in surface, usually bilaminar, dense, and imbricated. They are most abundant at the tip and sides of the tongue; those at the sides are distinguished as **lenticular papillæ**, those nearer the middle are **conical fungiform papillæ**. In each papilla are many vessels and double-contoured nerve-filaments from the lingual branch of the fifth nerve. These in the former end in taste buds, each of which is oval, a narrow end reaching the surface, a wider end resting on the basement membrane. They average about $80\ \mu$ in vertical, and $35\ \mu$ in transverse diameter. Each bud consists of a series of about thirty fusiform or flattened caraway seed-shaped *support cells*, sometimes branched, and always containing a roundish subcentral nucleus. These form a barrel-like sheath, within which are three to fourteen somewhat rod-like *gustatory cells*, each of which contains an ovate nucleus, surrounded by a small mass of protoplasm, from which a slender striated rod passes to the free

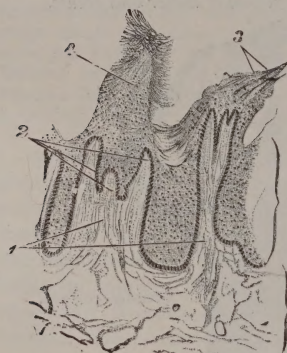


Fig. 668.—Filiform papillæ, $\times 30$ —1, primary papilla; 2, secondary papillæ on its summit; 3, double epithelial process on papilla; 4, single process, with entangled loose epithelial cells.

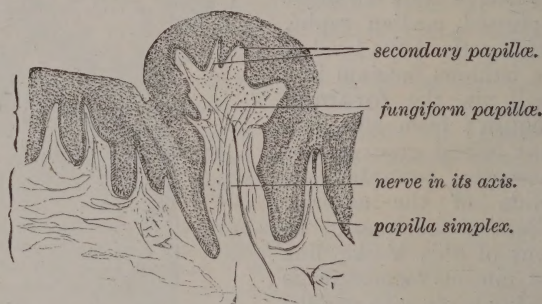


Fig. 669.—Fungiform papillæ, $\times 30$, lenticular form.

end of the bud, where there is a *gustatory pore*. The other end is continued into a delicate non-medullated process, which appears to become continuous with a nerve fibre (fig. 671).

In addition to these, there are numerous **simple papillæ** over the whole mucous membrane of the tongue, but they are so small that they do not project through the epithelium (fig. 669).

In front of the anterior pillar of the fauces, the side of the tongue presents a patch, whose borders are not clearly defined, and whose surface is divided by vertical grooves into a series of fine, but irregular, lamellæ. These are the rudiments of **papillæ foliatæ**, structures more perfectly developed on the tongues of many mammals, such as the hare, but they present but few taste-buds in the human tongue, and the papillæ with which they are clad are called **papillæ degenerantes**.

Behind and parallel to the V-shaped line there is a row of about ten large papillæ, the **circumvallate papillæ**. Each of these is conical, attached by its apex, which is sunk in a pit. The base of each is beset with papillæ, and into each there passes a branch of the dorsalis linguæ artery, and of the glossopharyngeal nerve. The sides of each of these papillæ are closely beset with taste buds, as are the opposed walls of the pits into which their apices are sunk.

The **foramen cæcum** is the remains of the embryonic *subtracheal tube*, the wall of whose fundus has developed into the thyroid body (§ 507). In 42 per cent. of tongues this pit receives the duct of a small gland.

Development.—The tongue is formed from the medio-ventral part of the back of the mandibular arch, and of the ventral ends of the second and third arches which project on the floor of the primitive mouth. Behind the middle of the mandibular arch there rises a median eminence, the tuberculum impar, which is separated from the mandibular arch by a shallow submaxillary groove, and from the ends of the two arches behind by a deeper groove, which medially sinks into a deep pit, the lingual duct, from the parts about whose fundus the middle part of the thyroid body arises. As growth proceeds, the ventral ends of the second and third arches on each side coalesce at their inner extremities, and extend behind the tuberculum impar to join their fellows of the opposite side, between the tubercle in front and the divided median eminence behind, from which the upper part of the larynx arises. Ultimately, the tuberculum becomes the body or trigeminal area of the tongue, its frænum being derived from its primitive union with the mandibular arch. The groove between the body and the united bases of the second and third arches behind become the V-line, along which the calyciform papillæ develop, and the part of the tongue behind it is the glosso-pharyngeal area, innervated by the nerve of the third arch. The prominent front edge of the second arch, as it rises outwards from the tongue, becomes the anterior pillar of the fauces; the hinder edge of the third arch becomes the lateral glosso-epiglottic fold; while the shallow pit, external to the coalesced ends of the second and third arches and between them, becomes the lower part of the tonsillitic recess. The frænum epiglottidis is a back-going fold from the back of the united third arches to the epiglottis. The tuberculum impar is a ventral portion of the hindmost cranial or first cervical metamere, interjected upwards between the ventral ends of the arches of higher metameres. It carries with it its innervation from the twelfth cranial nerve.

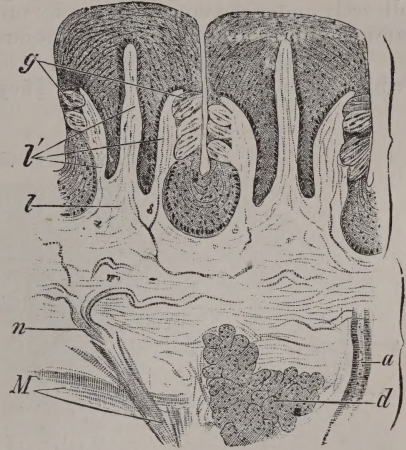


Fig. 670.—Papillæ foliatæ in the rabbit, $\times 80$ —*l*, *l'*, primary and secondary septa; *g*, taste buds; *n*, medullated nerve; *d*, aquirous gland; *a*, its duct; *M*, muscular fibres.

Besides the *extrinsic* muscles, such as *genio-glossus*, *hyo-glossus*, *stylo-glossus*, and *palato-glossus* (p. 586), which enter the tongue from without, there are in

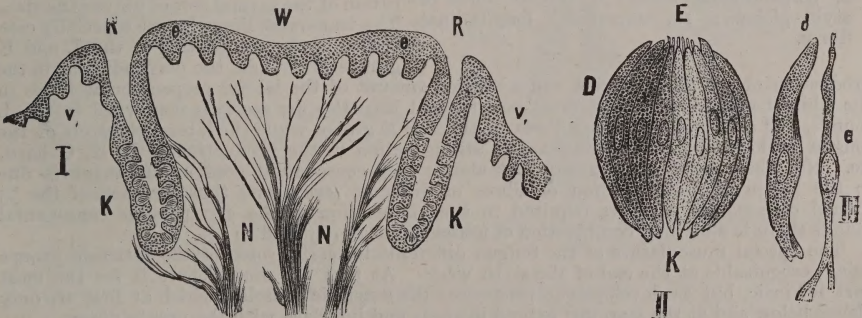


Fig. 671.—I. Circumvallate papillæ, transverse section—*W*, its free surface; *N*, its nerve; *R*, the fossa round it; *K*, taste buds in position; *v*, wall in section. II. Taste bulb—*K*, under end; *E*, free end open; *D*, protective cells. III. *d*, protective cell; *e*, taste cell.

the substance of the tongue many proper or *intrinsic* fibres which run their whole length in its substance and are closely connected by both ends to the mucosa. They can be traced most easily when the connective tissues have been softened by prolonged boiling, and are arranged in the following series (fig. 672):—

1. **Stratum longitudinale inferior** (*ib.*, 6), a thick rounded band of muscle, extending from base to tip, external to the *genio-glossus* and internal to the *hyo-glossus*; this bundle becomes flattened and lateralised as it passes forwards.

2. **Stratum longitudinale superior** (*ib.*, 10), extending from base to tip, directly under the mucosa of the dorsum. These fibres lie internal to the *hyo-glossus*, and the fibres are not in a continuous series but broken up into short fascicles.

3. **Stratum transversum**, over a hundred fascicles, mixed with fat, which pass from side to side. They end in the fibrous tissue of the septum

medially, and in the mucosa laterally; posteriorly, these fibres are connected with the *palato-glossus* and upper part of the *stylo-glossus* (*ib.*, 2).

4. **Stratum perpendiculare**.—

These fibres are really oblique, starting above from the mucosa of the dorsum, passing at first directly downwards, and then turning a little outwards to the mucosa of the side and back. These are most numerous in the free part of the tongue (*ib.*, 8).

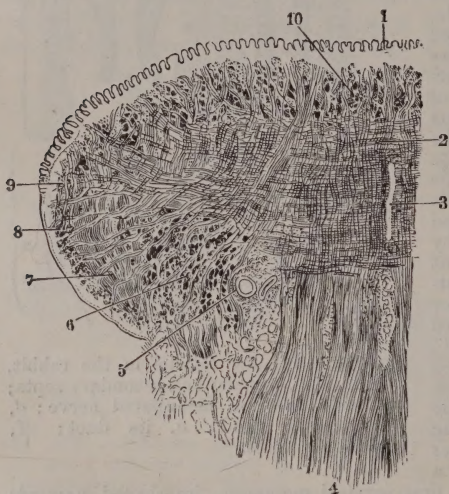


Fig. 672.—Coronal section of tongue, showing intrinsic muscles, $\times 2$ —1, papillae of dorsum; 2, stratum transversum; 3, septum; 4, genio-glossus; 5, lingual artery; 6, deep longitudinal lingualis, cut through; 7, fibres of hyo-glossus; 8, perpendicular fibres; 9, lateral fibres of stylo-glossus; 10, superficial longitudinal fibres.

The several elements in the lingual musculature are capable of a large amount of independent motion, hence the tongue can assume the differing forms required for the production of consonantal sounds, each of which can be anatomically defined in the terms of the fibres necessary for its production. There is reason to believe that the musculature of the tongue varies in different races owing to the hereditary practice and habitual use of certain motions required for enunciating the several vernacular languages. For the perfect formulation of these, however, in the equation form, a more minute and definite classification of the several sets of fibres is needed. The transverse linguales are especially concerned in the enunciating of the L and K groups of sounds, the perpendicular in the

production of the T D N series, and a varying amount of the lateral perpendicular fibres in the sibilant group. The superficial longitudinal linguales are specially concerned in the L sounds, and all the longitudinal fibres in the T D N group, while the lateral elevators of the tongue, stylo- and palato-glossus are in strong action in the production of R, K, G hard, &c. Not that any of these groups act alone; each consonantal contour of tongue is due to the action of a combination of fibres of different series, and thus for each of the 55 lingual consonantal contours required in the enunciation of the 260 possible consonantal sounds there is a distinct combination of muscular fibres required to act.

The special musculature of the tongue differentiates early, some of the intrinsic groups being recognisable at the end of the sixth week. At first the musculature is for the most part intrinsic, but as development progresses the extrinsic muscles, which at first are only placed below and at the margins, extend inwards and interlace with the proper fibres.

All these muscular fibres are separated by delicate connective sheaths and by small, soft fat cells. The fibres are rarely in right lines, most of them are curved, even weakly spiral, and some appear to be branched at their extremities.

The glands opening on the surface of the tongue are:—

1. **The apical glands of Blandin or Nuhn** (fig. 664), one on either side of the middle line between the *genio-glossi* internally and the inner surface of the stratum longitudinale inferior externally, and beneath the transverse fibres. These are made up of both aquiparous and mucous acini, and each opens by four ducts.

2. **Ebner's glands**, very small, aquiparous, and ptyalin-secreting glands, but with no processed cells, opening at the back of the upper surface, along the margins of the circumvallate papillae.

3. **Weber's glands** (fig. 158), mucous glands, whitish to the eye and abundant near the base of the tongue.

4. **Middle marginal glands**, shallow follicles, each with a median papilla. They extend forwards along the mucosa over the *stylo-glossus*.

5. **Posterior marginal**, a larger series, forming a compact mass on the surface behind the *stylo-glossus*, internal to the last molar tooth and to the buccinator crest on the lower jaw.

476. THE ANTERIOR PILLARS OF THE FAUCES OR GLOSSO-PALATINE FOLDS are two sharp crescentic folds which commence and pass laterally upwards and backwards from the sides of the tongue to the soft palate. Behind these a similar larger and longer, but more closely approximated pair of folds, the *posterior pillars of the fauces*, can be seen on looking through the mouth at the back of the throat. These arise from the uvula and descend backwards to the pharynx. Between these and the former is a somewhat triangular fossa, whose oblique base is below at the tongue, the **tonsillitic recess**. The dissection of these must be deferred for the present.

The **soft palate** (fig. 673) is a duplicature of thick mucous membrane, which forms the hinder part of the roof of the mouth, presenting an inferior concave or palatine surface, a superior convex or nasal surface, and a down-directed free border, in the middle of which hangs a soft, pointed process, the **uvula**. On each side of the uvula the border is crescentic, ending externally at the pillars of the fauces. Between these two layers of membrane are contained muscles and glands, and a central tough areolar layer, the palatine aponeurosis. When the mouth is shut, this partition is nearly closed, the space between it and the back of the tongue being very slight. The mucosa on the oral side, the only part which can be seen at present (and whose surface the student should examine with a mirror, in his own throat), is thinner than that on the dorsal aspect, and on each side presents the openings of many glands. When the epithelium is scraped off, these can be seen as distinct holes, about 100 in number, the largest glands being at the base of the uvula. In the uvula there are about twelve glands embedded in a soft connective tissue, in which lie some vertical muscular fibres. In its submucous layer are some elastic fibres which usually hold its tip bent forwards.

The **isthmus faucium** is the opening from the cavum oris into the pharynx, bounded above by the soft palate, laterally by the glosso-palatine folds, and below by the dorsum of the tongue. Its transverse diameter is one half that of the cavum, but varies momentarily with muscular action.

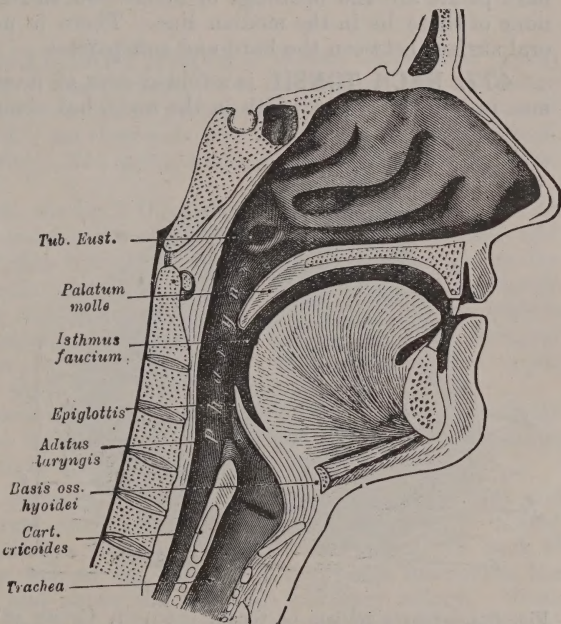


Fig. 673.—Sagittal median section through mouth and pharynx.

The **hard palate** is the concave vault within the semi-ellipse of the teeth, whose mucous membrane is continuous from the gums, and closely tied to the palatine periosteum, with no *muscularis mucosæ*. The surface becomes deeper in colour, and the submucous tissue thickens towards the soft palate.

Behind the incisor teeth is the **papilla palatina**, a somewhat pear-shaped median area, upon which open the rudimentary canals of Stenson. These are more easily seen on the nasal than on the oral side, and are often only represented by connective bands which pass into the nose through the anterior palatine foramen. Still farther back the palate presents in the fetus a series of 2 to 4 transverse ridges with somewhat pectinated surfaces, chiefly made up of thickened epithelium, clothing papillæ whose points are directed backwards. These become obscure, and irregular, even at birth; one usually remains over the premaxillary suture, one whole and some broken folds behind the incisors are presutural, three or four are post-sutural. In later life the palatine surface becomes rough from the development of secondary ridgings on the bone; a median longitudinal raphé often projects a short distance behind the palatine tubercle. On the surface of each side of the hinder portion of the hard palate are the openings of about 200 small, acinous, mucous glands, but none of these lie in the median line. There is no line of demarcation on the oral surface between the hard and soft palates.

477. EACH TONSIL is a folded area of mucous membrane, averaging 22 mm. in length by 9 in width in the male, but about 14 mm. long by 7 wide in the female. The surface is

very variable, sometimes depressed into one or more longitudinal slits, or else pitted into a series of rounded holes. In the mucosa lining each pit is a group of 10 to 12 lymphatic follicles, into the recesses between which small, acinous glands open. The tonsil is surrounded externally by a fibrous tunic connected with the submucous layer of the pharynx. When the internal carotid artery is tortuous, it lies close to its hinder and outer surface, separated therefrom by the superior constrictor muscle of the pharynx. The external carotid is not far from its outer surface, and a tortuous facial may lie close to its

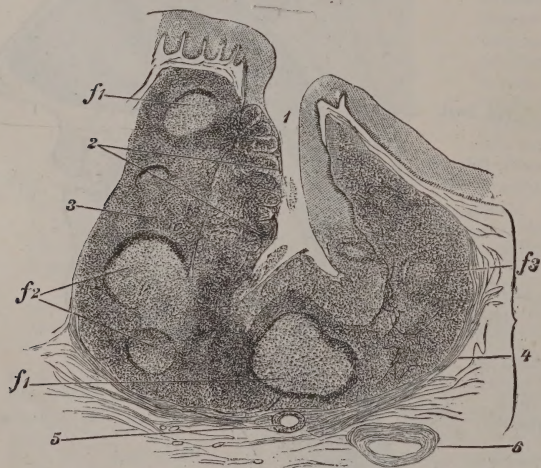


Fig. 674.—Single follicle of tonsil, $\times 20$.—1, Cavity of follicle; 2, epithelium containing leucocytes below and in the left nerve on the right; 3, adenoid tissue, *f1*, 2, and 3 portions of it condensed; 4, fibrous sheath; 5, section of duct of mucous gland; 6, blood-vessel.

front border. These facts must be borne in mind when the surgeon is called upon to open a tonsillitic abscess. Prominence of the tonsil is due to the amount of interstitial connective tissue in the organ as well as to increase in the size of the glands. A normal tonsil should not project beyond the glosso-palatine fold.

Subpharyngeal cartilage.—A nodule of hyaline cartilage, about the size of a small grain of corn, is usually placed beneath the mucous membrane, below and behind the tonsil, often attached to the fibrous capsule of the tonsil by an areolar band, to which a few straggling muscular fibres are attached; it bounds the passage of the glossal branch of the

glosso-pharyngeal nerve, and is a rudiment of an upper portion of the axis of the third post-oral arch. The vessels of the tonsil are derived from the tonsillar branch of the facial, and from the ascending palatine, as well as from the posterior palatine branch of the internal maxillary and dorsalis linguae; its veins pass into the pharyngeal plexus. Lymphatics are abundant, arising around the numerous follicles, and passing downwards into the submaxillary lymphatic glands, but the lymph spaces and tubes cannot easily be shown to communicate directly with the follicle.

A more or less thick layer of lymphatic follicles extends from one tonsil to the other tonsil across the back of the tongue, opening into the numerous crypt-like hollows which pit the surface of this organ (fig. 158). This streak is, however, on that part of the tongue which lies behind the isthmus faucium, and is consequently in the pharynx. The dissection of the parts which underlie the mucous membrane of the hard and soft palate cannot be proceeded with until a deeper dissection is made.

The tonsils are the first of a large series of lymphatic follicles which, from this downwards, are found in the lining membrane of the alimentary canal, out of which immense numbers of white corpuscles wander into the cavity of the tube, there to be mixed up with the food. These corpuscles pass through the capsules of the follicles, and between the overlying epithelial cells.

Dissection.—The auriculo-temporal nerve having been separated from the back of the capsule of the lower jaw, and the ligaments of that joint having been reviewed; (p. 243), disarticulate the head of the lower jaw from the glenoid cavity and draw it forwards, thereby the inferior maxillary branch of the fifth nerve is shown as it escapes from the foramen ovale.

478. THE INFERIOR MAXILLARY NERVE.—Within the cranium (§ 516) this nerve appears in Meckel's space, arising from the front, lower, and outer part of the Gasserian ganglion; the motor portion underlying the sensory, and being at first separate from it. As they pass out the two roots partly blend, forming the plexus of Santorini. The motor fibres, however, keep for the most part on the outer side.

Having made its exit from the skull through the foramen ovale the inferior maxillary nerve lies at first under cover of the external pterygoid muscle, and here it gives off (1) a **recurrent** branch, which ascends into the cranial cavity through the foramen spinosum, and is distributed by anterior and posterior branches to the dura mater and bone, communicating with the sympathetic nerves round the middle meningeal artery, and with a recurrent meningeal branch of the otic ganglion; a small filament is distributed to the upper mastoid cells.

The inferior maxillary trunk divides, 2 mm. below the skull, into an inferior and a superior branch. The former descends internal to the pterygo-spinous ligament, and immediately divides into three branches:—

1. **Auriculo-temporal** (sensory).—This arises by two roots (fig. 659), one smaller in front and one larger behind the middle meningeal artery. These unite, and the trunk, descending a little backwards, winds round the back of the capsule of the lower jaw, behind the condyle of that bone, internal to the external pterygoid muscle, and above the internal maxillary artery. From thence it ascends, at first in front of, then through, the parotid gland, anterior to the ear, and behind and beneath the superficial temporal artery. It receives three small branches from the otic ganglion, which join its roots before their union. It gives off (a) *articular branches* to the capsular ligament of the lower jaw; (b) *parotid branches*, with which the secretory nerve filaments, derived primarily from the glosso-pharyngeal nerve and received from the otic ganglion, leave the nerve and are distributed to the gland (fig. 666); (c) *two meatus branches*, an upper and lower, distributed to the skin lining the upper and lower parts of the outer ear tube respectively, the upper branch supplying also the outer surface of the membrana tympani; both communicate with branches of the great auricular (p. 542); (d) *two branches* to the facial nerve, which cross the temporal artery and blend, and are distributed with the upper branches of that nerve; (e) *anterior auricular*, lost on the skin of the

tragus and vicinity of the intertragic notch, (*f*) communicating with the temporal branch of the superior maxillary; (*g*) the *terminal* branch ascends beneath the superficial temporal artery to the skin of the temple on a plane in front of the ear (fig. 625.)

2. The **inferior dental** (fig. 675, 5) is the largest branch, and descends between the two pterygoid muscles, below the auriculo-temporal, and posterior and external to the other branches of the inferior maxillary. Having passed between the speno-mandibular ligament and the neck of the lower jaw, below the internal maxillary artery, it enters the inferior dental canal in the mandible accompanied by the inferior dental branch of the internal maxillary artery, which passes below and behind it. As it passes into the canal it gives off its motor branch, the **mylo-hyoid nerve** (fig. 675, 6, 10), and its stem is continued forwards and inwards in the inferior dental canal, with the artery of

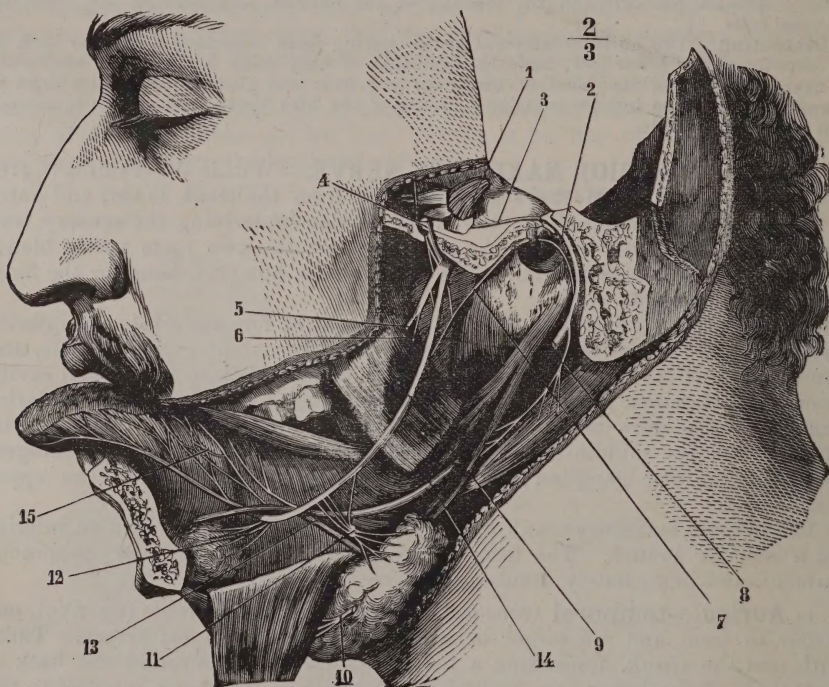


Fig. 675.—Dissection of the inferior maxillary nerve; the submaxillary gland being drawn downwards to show the submaxillary ganglion (11)—1, Gasserian ganglion; 2, facial nerve in the aqueduct of Fallopius; 3, great superficial petrosal; 4, cut and reflected auriculo-temporal; 5, cut inferior dental; 6-10, mylo-hyoid nerve; 7, chorda tympani; 8, branch of facial to the digastric and stylo-hyoid; 9, lingual branch of fifth; 12, sublingual branches; 13, Wharton's duct; 14, hypoglossal nerve; 15, communications of lingual and hypoglossal nerves.

that name below it. It gives off fine *inferior dental* branches from its upper surface to the pulp canals of all the lower jaw teeth, and *gingival* branches to the lower gums. These nerves form in the bone an infra-alveolar plexus before they finally pass to their destinations.

Opposite the mental foramen this nerve sends to the surface a large *mental nerve*, accompanying the mental artery from the inferior dental (p. 583), and distributed by one small twig to the skin of the chin, and by two larger branches to the lower lip (fig. 614).

The mylo-hyoid nerve (fig. 675, 6-10) pierces the insertion of the speno-mandibular ligament, descends above or through the insertion of the *internal pterygoid* muscle to the lower surface of the *mylo-hyoid* muscle and the anterior belly of the *digastric*. This nerve unites by a cross branch through the *mylo-hyoid* with a branch of the lingual.

3. The **lingual** nerve (fig. 675, 9) is sensory, and descends at first between the two *pterygoid* muscles, internal and in front of the inferior dental nerve. It then lies between the *internal pterygoid* muscle and the speno-mandibular ligament on the inner side of the internal maxillary artery, and finally it descends on the front surface of the *internal pterygoid*, having the body of the jaw external to it and lying under the mucosa of the mouth. Its course is curved, its concavity being directed upwards and forwards, and it lies in the floor of the cavum oris on the *stylo-* and *hyo-glossus* muscles (fig. 677, 9), having the submaxillary gland and *mylo-hyoid* muscles below and superficial to it. Entering the side of the tongue, it passes through the fibres of the inferior *lingualis* muscle, and is distributed to the mucosa through the *genio-* and *hyo-glossi*. It crosses beneath and to the inner side of the Whartonian duct.

Where this nerve lies superficially in the cavum oris, between the level of the last molar tooth and the angle of the jaw, it is easily reached, and it has been recommended to cut it here as a palliative in intractable, painful diseases of the tongue.

It receives a small *communicating branch* from the inferior dental close to its origin, and while it lies above the *internal pterygoid*, a little higher up it receives on its hinder side the *chorda tympani* nerve (figs. 675; 677, 12), which descends forwards towards it from the canal of Huguier (p. 220).

It gives off—1. Two communicating branches to the submaxillary ganglion. Of these the hinder passes forwards and downwards into the ganglion, while the second passes from the ganglion back into the trunk of the nerve (fig. 679, L).

479. THE SUBMAXILLARY GANGLION (figs. 675, 11; 677, 2; 679, L) can be found by tracing the lingual nerve downwards to the back of the submaxillary gland, above and behind which it lies, close to the root of the Whartonian duct, and at the level of the last molar tooth, at the hinder border of the *mylo-hyoid* muscle, being separated from the mucous membrane of the mouth by the trunk of the lingual nerve. It is a small fusiform ganglion about 3 mm. long, into which the fibres from the *chorda tympani* for the most part pass, together with some sensory filaments from the lingual itself; sympathetic fibres from the plexus round the facial artery also join it (fig. 679, q). Its branches are about four fine threads which pass along the branches of the Whartonian duct to the submaxillary gland, conveying the secretory fibres from the *chorda tympani*, stimulation of which causes an increased flow of saliva. It also sends off a bundle of recurrent fibres to the lingual nerve, and several communicating filaments to the hypoglossal.

Beyond the submaxillary ganglion the lingual gives off:—

2. A large *communicating branch*, which crosses the *hyo-glossus* muscle to join the hypoglossal nerve, bringing sensory filaments to the branches of that nerve.

3. A few *mandibular* filaments pass to the mucosa of the floor of the mouth, close to the gums of the molar teeth.

4. A *sublingual* branch, which passes external to and supplies the sublingual gland, the gums, and the mucosa beneath the tongue. A few fibres of the *chorda tympani* traverse this to the glands, but do not form a recognizable sublingual ganglion.

5. The *terminal* branches, which traverse the muscles to the superficial mucosa of the tongue, are numerous, and end in the papillæ of the sides, back, and tip. Most of them are nerves of common sensation, but a few

contain gustatory fibres, derived through the chorda tympani from the glosso-pharyngeal.

480. III. THE SUPERIOR BRANCH OF THE INFERIOR MAXILLARY is smaller, and for the most part composed of motor fibres. It passes above and external to the pterygo-spinous ligament, and divides almost at once into five branches—

1. **Internal Pterygoid Nerve.**—This arises from its anterior and inner side and usually passes close to the otic ganglion (fig. 676, 6), descending to the inner surface and upper part of the muscle to which it is distributed. On its way thither it gives off—(a.) *nerve to the tensor palati*, which turns downwards and forwards immediately below the otic ganglion (ib., 7), and enters this muscle on its hinder and inner side; (b.) *nerve to the tensor tympani*, which crosses the inner side of the otic ganglion, but is unconnected with it, and supplies the *tensor tympani* within its canal (ib., 9); (c.) *the motor root to the otic ganglion*.

2. **Buccal nerve** arises external to the last nerve, and is the only sensory branch of this division. It usually escapes between the two heads of the

external pterygoid muscle and descends forwards close to or piercing the front border of the *temporal* tendon, from whence it passes beneath the buccal pad of fat to the outer surface of the *buccinator*; here it divides into two sets of filaments, a superficial which pass to the skin of the cheek, a deeper set to the mucosa of the cheek. It is accompanied by the buccal branch of the internal maxillary artery (p. 583). It communicates with filaments of the infraorbital, of the lingual, and of the facial nerve.

3. **External pterygoid nerves**, a cluster of filaments arising external and posterior to the buccal as it is about to pierce the *pterygoid* muscle, and is distributed to its muscle.

4. **Anterior deep temporal** arises a little in front of the buccal, and turns upwards upon the great wing of the sphenoid, above the outer *pterygoid* muscle, to end in the anterior part of the *temporal* muscle.

5. **Posterior deep temporal** is larger, and passes behind the other branches close to the temporal bone, which it often grooves, and above the *external pterygoid* muscle. It divides behind the *temporal* tendon of the muscle into two branches—(a.) *masseteric*, which passes outwards through the

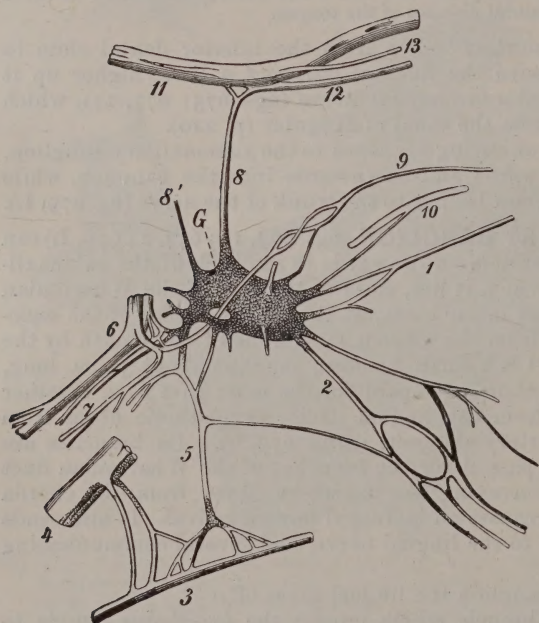


Fig. 676.—The otic ganglion, G—1, lesser superficial petrosal; 2, branches to the auriculo-temporal; 3, chorda tympani; 4, lingual of fifth pair; 5, branch to the chorda tympani; 6, internal pterygoid nerve; 7, branch to tensor palati; 8, branch to Meckel's ganglion; 9, nerve to the tensor tympani; 10, recurrent meningeal of inferior maxillary.

sigmoid notch to enter the deep surface of the *masseter* muscle; (b.) *posterior temporal*, which ascends over the crista infratemporalis, and divides into two branches to supply the hinder part of the *temporal* muscle.

481. THE OTIC (ARNOLD'S) GANGLION (fig. 676), a flattened oval body 4 mm. long, which lies with its long axis sagittally disposed beneath the foramen ovale on the inner side of the trunk of the inferior maxillary nerve, and surrounding the root of the internal pterygoid nerve. It receives three roots—one motor, often plexiform from the internal pterygoid nerve; a second sensitive or probably mixed, the *lesser petrosal* which emerges to join it from a perforation in the hinder border of the ali-sphenoid, and conveys to it filaments from the glosso-pharyngeal (fig. 679); a third, or sympathetic root, which comes from the plexus around the middle meningeal artery, but it is doubtful whether these filaments really end in the ganglion as they seem to end in the wall of the *meningea parva* artery.

The branches arising from the otic ganglion are—(1) filaments to the auriculo-temporal (p. 597); (2) filaments to the chorda tympani, most of which pass peripherally in that nerve to the tongue, a few probably run backwards to join the facial trunk; (3) three fine branches which join the buccal nerve; (4) a very fine communicating branch to the nerve to the *tensor tympani*; (5) a branch which traverses a minute canal in the sphenoid from the foramen ovale inwards to join the recurrent meningeal branch of the inferior maxillary nerve; (6) a fine communicating branch which enters the Vidian canal and passes to end in the pheno-palatine ganglion.

482. THE HYPOGLOSSAL (fig. 677, 8), the twelfth cranial nerve, can be traced upwards in the present dissection almost to its aperture of emergence, the anterior condyloid hole; within the cranium its twelve or fourteen bundles of filaments can be seen uniting into two clusters which pierce the dura mater separately and unite in the anterior condyloid foramen into one cord. As it emerges from the skull it lies deeply in the neck and passes between the internal jugular vein and the internal carotid artery (fig. 663). The hypoglossal is at first internal and posterior to the vagus, to which it is closely united by a connective sheath; but it soon passes external to that nerve, and then descends forwards under the hinder belly of the *digastric* and the *stylo-hyoid* muscles, and, having hooked round the sterno-mastoid branch of the external carotid, or, in its absence, the occipital artery, it turns forwards superficially over the external carotid and facial arteries beneath the temporo-maxillary and facial veins. Passing beneath the submaxillary gland and the *mylo-hyoid* muscle, it crosses the *hyo-glossus* below Wharton's duct to enter the tongue, wherein it lies internal to the lingual artery, between the *lingualis* and *genio-glossus* muscles.

The hypoglossal is the motor nerve to the muscles of the tongue, and is a cervical nerve in lower vertebrates. Even in man it preserves its cervical connections which are essentially united with the branchings of the cervical plexus (fig. 627). At its exit from the skull it consists of over 5,000 large nerve fibres. In the early embryo this nerve is remarkable for its enormous proportional size.

The hypoglossal receives, immediately below the condyloid foramen—(1) an ascending loop of communication from the first and second cervical nerves, which comes off close to the exit of the anterior branch of the first cervical nerve. The course of the fibres of this loop have been already traced (p. 544). A centripetal twig ascends into the nerve root from the first cervical, but its ending is uncertain; (2) a branch from the vagus which passes downwards into the stem of the nerve; (3) lower down, where it lies beneath the *mylo-hyoid*, it receives a communication from the lingual branch of the fifth before described.

The hypoglossal nerve gives off—1. A white ramus communicans to the superior cervical sympathetic ganglion.

2. A recurrent branch, which ascends through the anterior condyloid foramen, and is distributed to the dura mater lining the occipital bone.

3. The afferent branches—descendens noni, thyro-hyal, and genio-hyoid—have been already described as cervical branches (p. 544), but it is probable that they carry with them as well some genuine hypoglossal filaments.

4. The terminal branches have been already seen breaking up to supply the *stylo-glossus*, *hyo-glossus*, *genio-glossus*, and the several series of intrinsic lingual fibres (fig. 677).

Dissection.—The posterior belly of the *digastric*, if not already divided, may now be reflected backwards, and the external carotid divided close to the origin of its temporal branch, and thrown downwards and forwards, the occipital and posterior auricular branches being also cut.

483. THE STYLO-PHARYNGEUS MUSCLE (fig. 684) thus exposed arises from the base and inner surface of the styloid process by short tendinous fibres, and descends a little forwards and inwards to enter the wall of the pharynx, under cover of the edge of the *middle constrictor*. It is inserted partly into the hinder edge of the thyroid cartilage, partly into the hinder wall of the pharynx, and partly into the lateral edge of the epiglottis internally. This muscle intervenes between the internal and external carotid arteries. The glosso-pharyngeal nerve winds round it from behind forwards, and supplies it; and lower down this muscle separates the *middle* from the *inferior constrictors* of the pharynx.

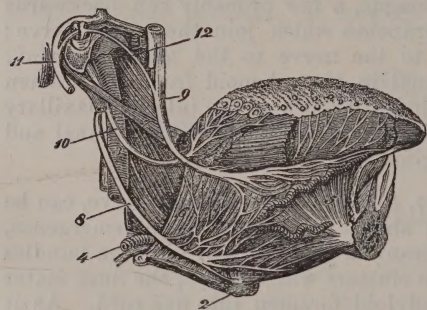


Fig. 677.—Dissection of the three nerves of the tongue, showing their curved courses and terminations—1, mandible; 2, hyoid bone; 3, internal carotid; 4, lingual artery; 5, genio-glossus; 6, hyo-glossus; 7, stylo-glossus; 8, hypoglossal nerve; 9, lingual branch of fifth nerve; 10, glosso-pharyngeal nerve; 11, facial; 12, chorda tympani.

The three styloid muscles thus appear to belong to different systems and differ in their innervation (see pp. 557, 586). The *stylo-glossus* is separated from the *stylo-pharyngeus* by the ascending palatine artery, and the *stylo-hyoid* from the two deeper muscles by the external carotid.

Dissection.—The styloid process is now to be divided at its base with the bone forceps, and thrown downwards and forwards, thereby the internal carotid in its first or cervical stage is exposed.

484. THE INTERNAL CAROTID ARTERY (fig. 678), the cervical continuation of the dorsal aorta upwards, is the channel for the supply of arterial blood to the chief part of the brain and the orbit, and pursues a singularly tortuous course upwards. It may be divided into three stages—cervical, intra-osseous and intra-cranial. This vessel is embryonically much larger than the external carotid, but as age advances towards maturity, the external carotid gradually enlarges until the two branches become nearly equal. The internal carotid arises from the bifurcation of the common carotid (p. 557) opposite the third cervical vertebræ or the superior cornu of the thyroid cartilage, and in its first stage ascends tortuously to the foramen caroticum in the petrous bone. It is at first curved with an outward convexity, and lies external to the external carotid. Nearer the skull it has a slight sagittal curve, with its concavity forwards. It lies on the vertebral column, the *rectus capitis anticus major*, and the superior cervical ganglion of the sympathetic, from which it is

separated by the superior laryngeal nerve. Still higher the hypoglossal, glosso-pharyngeal, and vagus nerves pass behind it, separating it from the internal jugular vein. This vein lies at first to its outer side, but close to the skull becomes posterior and external. To its *inner side* lie the pharynx, tonsil, and ascending pharyngeal artery, and it is covered by the *digastric* and *stylo-hyoid* muscles, the external carotid, the *stylo-glossus* and *stylo-pharyngeus* muscles, the hypoglossal and glosso-pharyngeal nerves, occipital artery, the parotid gland, and the ascending palatine artery. At the base of the skull the Eustachian tube and the *levator palati* overlap it. No branches arise in this first stage.

485. INTERCAROTIC BODY.—Between the external and internal carotid arteries there is a tough, elongated, greyish body, made up of fine blood-vessels from the common and external carotid, a few non-medullated nerves and ganglion cells, and a mass of connective tissue. This is the remains of a vascular rete, probably that of the second visceral cleft (fig. 678).

The remaining portion of the internal carotid can only be seen in a later dissection (p. 680).

The deeper nerves of the side of the neck may now be conveniently examined, although some of their relations at the base of the skull will be better seen at a little later stage. The pharyngea ascendens artery (p. 562) can also be seen at present.

486. THE GLOSSO-PHARYNGEAL NERVE, OR NINTH CRANIAL

(figs. 677, 10; 679), leaves the cranial cavity through the middle division of the jugular fossa in the form of two cords. These are

separated from the tenth and eleventh nerves by a fine bridge of dura mater, and unite in the jugular hole to form a gangliform swelling, the **ganglion jugulare** (Ehrenritter's ganglion), which lies inferiorly at the foremost part of the jugular foramen. As the nerve escapes extracranially it enlarges into a distinct ganglion, the **petrosal**, or Andersch's ganglion (of which indeed the superior or jugular ganglion is only a premature lobe, not a separate structure). This is a small, somewhat rounded, mass, about 4.2 mm. long, which lies in a small pit in the petrous bone (fig. 679). The trunk of the nerve below the ganglion passes between the outer side of the internal jugular vein and the internal carotid artery, then between the outer side of the internal carotid artery and the overlying *stylo-pharyngeus* muscle. It then winds round the *stylo-pharyngeus* from behind and without to its forward and inner side, forming a curve whose concavity is upwards and inwards, nearly parallel to, deeper than, and between the curves of the two other nerves; passing to the tongue, it finally descends beneath the border of the tonsil and subtonsillar cartilage to the

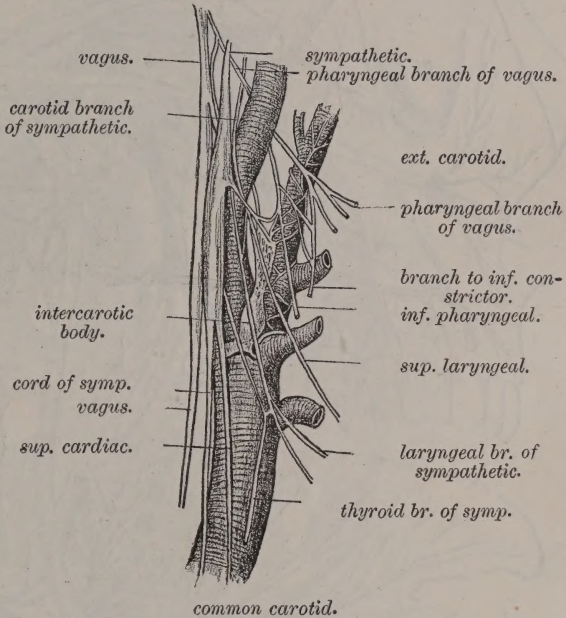


Fig. 678.—Hinder view of the bifurcation of the right common carotid artery.

mucous membrane of the tongue, below and internal to the anterior pillar of the fauces, to end in the lingual mucosa in and around the circumvallate papillæ (fig. 679, U).

The branches of the glosso-pharyngeal nerve pursue many and devious

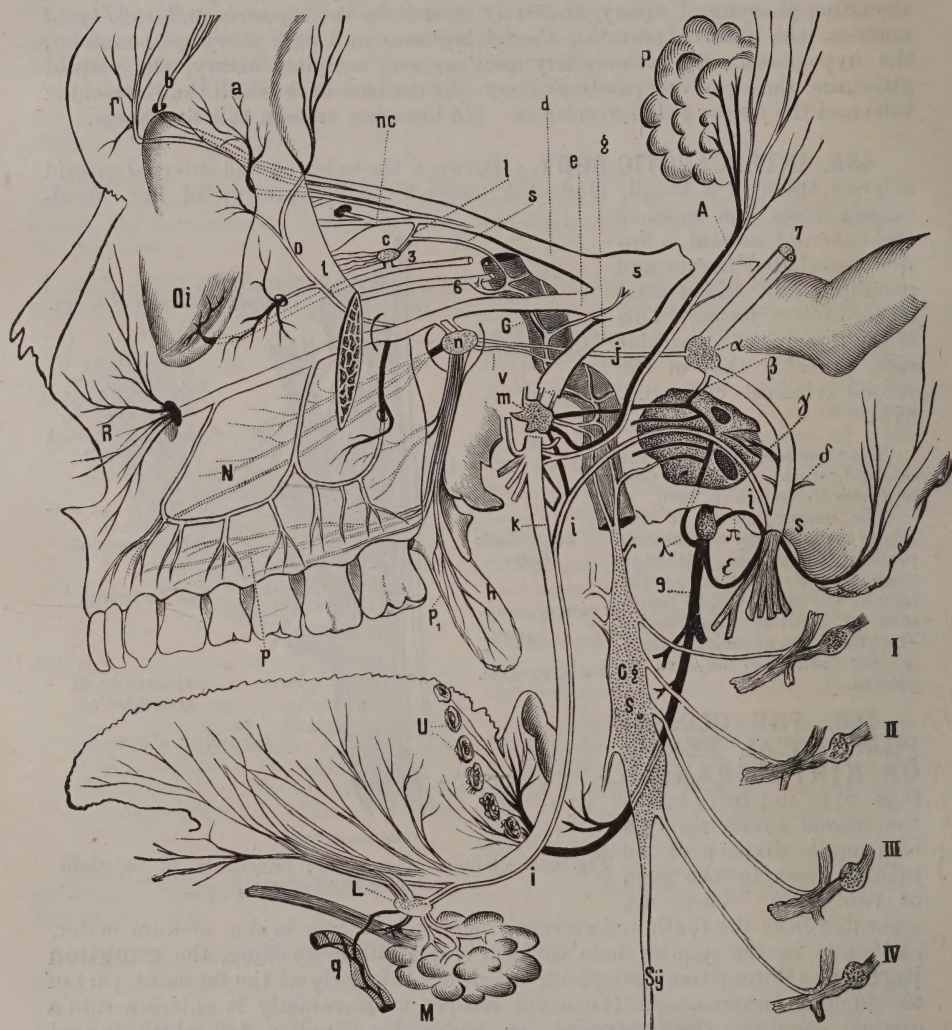


Fig. 679.—Schematic view of the fifth nerve and its connections—3, third nerve; 5, Gasserian ganglion of fifth; 6, sixth nerve; 7, seventh nerve; 9, ninth nerve; s, superior ganglion of sympathetic; i, chorda tympani; R, lingual branch of fifth; m, otic ganglion; q, sympathetic root for submaxillary ganglion, L; M, submaxillary gland; U, calyciform papillæ.—(For other references see §§ 532, 537.)

courses, and cannot be seen in any one dissection. They may be grouped into those arising from the ganglion of Andersch and those from the nerve itself.

The branches of other nerves which pass to join the glosso-pharyngeal at the ganglion of Andersch are (1) a few fine filaments from the facial which join the tympanic plexus, and pass backwards along the tympanic nerve to the

ganglion. (2) The *carotico-tympanic* which springs from the outer branch of the carotic plexus, and pierces through the wall of the vertical part of the carotid foramen to enter the tympanum, within which it joins the tympanic nerve. (3) Motor branches from the eleventh pair, these enable it to innervate some muscles.

Arising from the ganglion are the following branches:—

1. **Tympanic or Jacobson's Nerve** (fig. 679, λ).—This ascends through a minute tympanic canaliculus on the anterior wall of the jugular fossa, where it is surrounded by a pseudo-ganglionic enlargement, the **corpus**

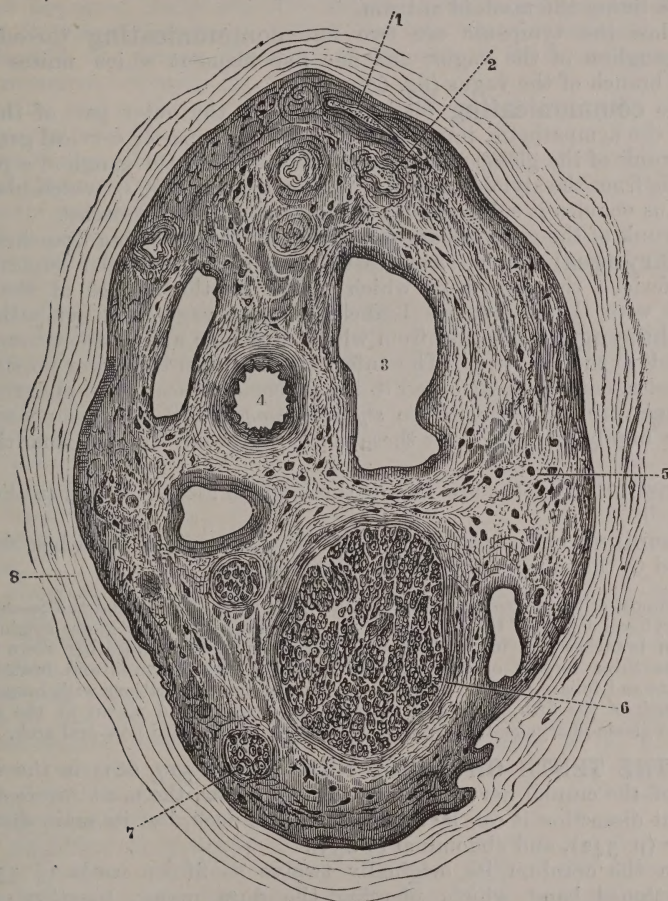


Fig. 680.—Section of corpus tympanicum around (6) the tympanic branch of the glosso-pharyngeal in its canal, $\times 200$ —1, capillaries; 2, small vein; 3, larger vein; 4, tympanic branch of pharyngea ascendens artery; 5, cells in parenchyma of body; 6, tympanic nerve; 7, small branch beside main stem; 8, bony boundary.

tympanicum of vessels and connective tissues. It enters the cavity of the tympanum where it lies in a groove on the wall of the promontory. From this it is continued upwards as the *lesser superficial petrosal nerve*, which passes out through the superior tympanic canaliculus into the middle fossa of the cranium, and thence through the innominate canal to the otic ganglion. In the course of this nerve, from the ninth to the fifth, are

conveyed (*a.*) the secretory fibres to the parotid and (*b.*) gustatory fibres to the chorda tympani, as well as (*c.*) sensory fibres to the lining of the Eustachian tube, and (*d.*) a branch derived from the tympanic, united with accessory fibres from the carotico-tympanic, which passes through the minute canaliculus petrosus into the outer wall of the horizontal part of the carotid canal, and there joins the carotid plexus and usually also the great superficial petrosal. This is the *nervus petrosus profundus minor*. (*e.*) Fine branches pass to the lining mucous membrane of the tympanum, one to the fenestra rotunda, one, often bearing ganglion-cells, to the fenestra ovalis, and one to the membrane lining the mastoid antrum.

2. Below the tympanic are two fine **communicating** threads to the jugular ganglion of the vagus, and one fine filament which unites with the auricular branch of the vagus (fig. 679, π).

3. One **communicating** filament passes to the outer part of the carotid plexus of the sympathetic, immediately above the superior cervical ganglion.

The trunk of the glosso-pharyngeal receives below the ganglion a peripheral motor twig from the styloid branch of the facial nerve (*ib.*, ϵ), which blends with it, and thus enables it subsequently to innervate certain muscles.

The trunk of the glosso-pharyngeal gives off the following branches:—

1. **Pharyngeal** branches, at least two, a slightly smaller superior and a larger inferior; the former of which unites on the surface of the *superior constrictor* with the pharyngeal branches of the vagus and sympathetic, and form a **pharyngeal plexus**, from which muscular and sensory branches are distributed to the pharynx. The inferior passes into the lower portion of the plexus, and is entirely distributed to the mucous surface of the pharynx.

2. **Muscular** branches to the *stylo-pharyngeus* and to the mucosa internal to it, it is highly probable that these motor fibres are derived from the spinal accessory.

3. **Tonsillar** branches are two or three which ascend to end in the mucosa of the tonsil.

4. **Terminal** or gustatory portion breaks up into branches which are distributed to the mucous membrane of the tongue.

The hindmost of these consist of four fine branches which end behind the foramen cæcum on the pharyngeal aspect of the tongue and the membrane lining the glosso-epiglottic fossæ. Two median branches pass inward to the foramen cæcum, communicating there with their fellows; the three largest of the terminal branches pass forwards and inwards to the circumvallate and foliate papillæ. These have several communications with branches of the lingual branch of the fifth, and form an irregular loose-meshed plexus in the submucous tissue. The glosso-pharyngeal is essentially the nerve of the third post-oral arch.

487. THE TENTH OR VAGUS NERVE (figs. 517, 681) is the most far-reaching of the cranial nerves and, in some respects, the most interesting. In the present dissection it can be traced down the neck, but its main distribution is thoracic (p. 342), and abdominal (§ 253).

Within the cranium its originally twelve to fifteen cords (§ 538) unite into a flattened band which, piercing the dura mater, together with the eleventh nerve, escapes behind the ninth nerve through the jugular foramen. A sheath of dura mater separates it from the ninth in front, and from the jugular vein behind. Within the jugular canal its fibres form a **jugular ganglion** (fig. 681); a small transversely elongated swelling, bulging chiefly on the inner side of the nerve and 5 mm. broad. Outside the canal, below this ganglion, the vagus is joined by the inner subdivision of the eleventh nerve (*accessorius vagi*), and enlarges into a long cylindroid **ganglion cervicale vagi** (*ib.*, 3), through which the fibres of the accessorius pass unchanged. This ganglion averages 16 mm. in length and 5 in breadth.

The ganglion cervicale lies behind the glosso-pharyngeal, in front of the

beginning of the jugular vein and the spinal accessory nerve, and internal to the hypoglossal. It then enters the sheath of the vessels, and descends in the neck, having first the internal then the common jugular vein to its outer side, and on its internal side it has the internal carotid artery above, the common carotid below. It is enclosed in a fascial sheath, and is separated from the vein by a weak, and from the artery by a strong septum. (Its thoracic course is described at § 431.) Having reached the superior opening of the thorax, the right vagus crosses over the subclavian artery here being slightly redder than above and a little dilated, and here it sends off the recurrent laryngeal nerve and the superior vagus cardiac branch. On the left side it enters the thorax behind the left vena innominata, to the left of the carotid, and crosses the front of the arch of the aorta, here giving off the left recurrent laryngeal (fig. 609).

From its origin, the vagus contains within it sensory, motor, inhibitory, secretory, and vessel-supplying fibres.

Above the ganglion jugulare the vagus receives one or two minute branches from the glosso-pharyngeal, and a fairly strong communicating branch from the superior cervical sympathetic ganglion.

It gives off (1) **recurrent meningeal** branches distributed to the dura mater over the sigmoid and inferior petrosal sinuses, and to the walls of these sinuses and to the posterior fossa.

(2) **Auricular branch** (Arnold's—fig. 681, *au*).—This nerve arises from the lower end of the jugular ganglion, and traverses a canal in the outer wall of the jugular fossa, enters and crosses the aqueduct of Fallopius above the stylo-mastoid foramen, here sometimes sending a filament into the facial nerve, and escapes to the superficial parts in the tympanico-mastoid fissure. Here it divides into two, both of which communicate with the posterior auricular branch of the facial (§ 456), and supply the back of the concha. It is the remains of the nerve of the wall of the first post-oral slit.

The vagus in the neck sends a branch to the superior cervical ganglion, and possibly also to the hypoglossal. This union is, however, extremely uncertain.

The ganglion cervicale sends off two **pharyngeal** branches between the external and internal carotids, which join the pharyngeal branches of the ninth. The upper of these is the larger, arises from near the upper end of the ganglion, and consists chiefly of fibres derived from the accessorius, the lower, arising near the middle of the cervical ganglion is smaller. The branches of this plexus lie on the lateral wall of the *middle constrictor*, and form close-meshed plexuses in the muscles and mucosa of the pharynx, and have often minute ganglia in their meshes. The lowest branch of the pharyngeal plexus sends a minute thread to join the hypoglossal nerve as it overlies the external carotid artery.

The **superior laryngeal** is a large cord which arises from the vagus below the ganglion cervicale, and lies at first behind the internal carotid artery, and on the superior cervical ganglion of the sympathetic. It then intervenes between the lingual artery superficially, and the *middle constrictor* which is beneath it, and lastly pierces the thyro-hyoid membrane.

While crossing the *middle constrictor* it divides into two branches, external and internal. The *external* is very small, chiefly motor, and receives sympathetic filaments from the superior ganglion, descends along the upper edge of the *inferior constrictor*, to which it generally gives a fine branch. It lies behind the sheath of the vessels, and is distributed to the *crico-thyroid* muscle, and by several minute branches, which enter the larynx, to the mucosa of the respiratory area of the rima glottidis (p. 625).

The *inner branch* is the larger, and is sensory. It enters the foramen

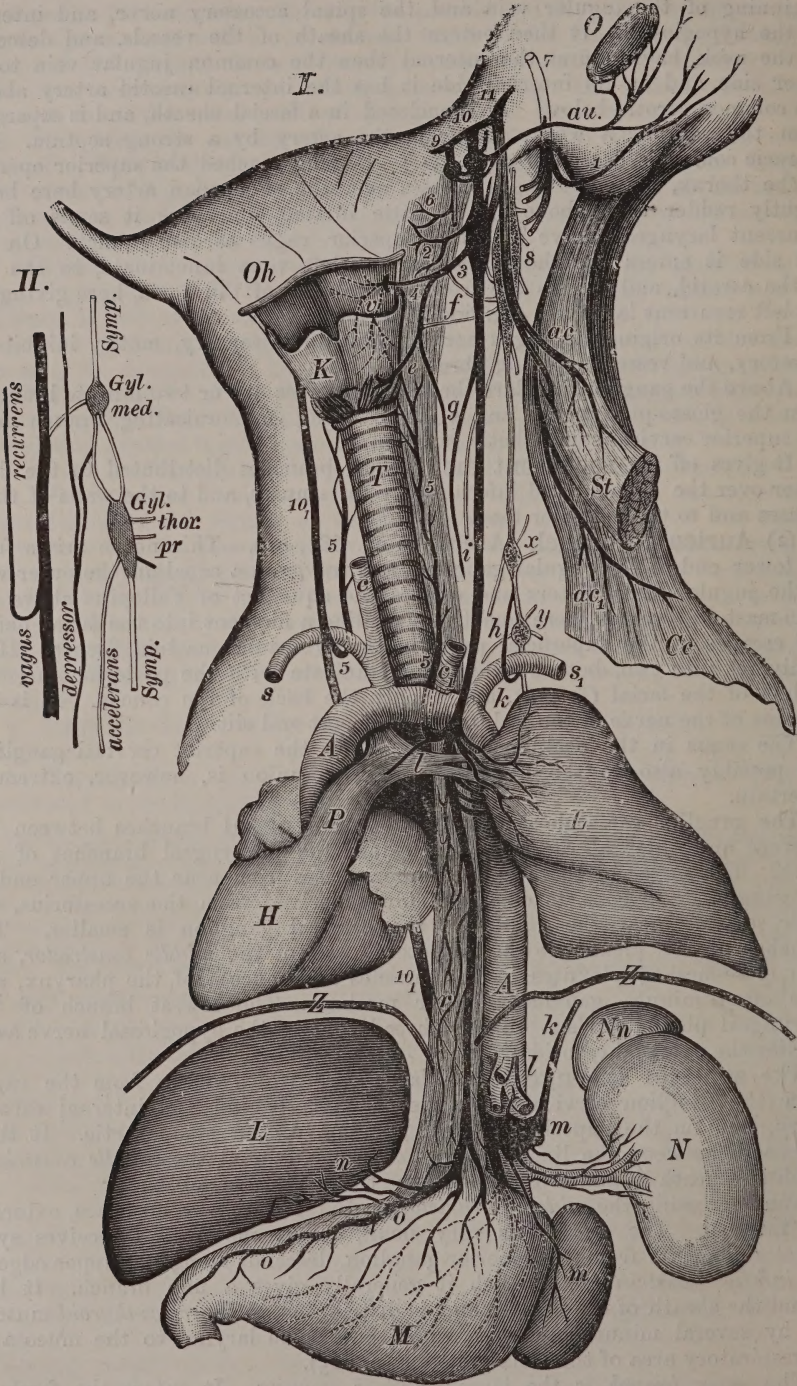


Fig. 681.—Diagram of the course and distribution of the vagus—1, posterior auricular of facial; 2, pharyngeal branch of vagus; 3, superior laryngeal; 4, external laryngeal; 5, recurrent laryngeal; 6, pharyngeal branch of ninth nerve; 7, facial; 8, sympathetic ganglion; 9, glosso-pharyngeal; 10, vagus; 11, spinal accessory; A, aorta; H, heart; K, larynx; L, lung; L', liver; M, stomach; N, kidney; Nn, suprarenal body; Oh, hyoid bone; O, ear meatus; P, pulmonary artery; T, trachea; Z, diaphragm; St, sternomastoid; Cc, trapezius; au, auricular branches of ninth and tenth nerves; ac, spinal accessory nerve; c, carotid artery; s, subclavian artery; f, anastomosis of sympathetic and external laryngeal nerves; x, middle cervical ganglion; y, inferior ganglion; k, ansa of Vieussens; g, i, h, the three cardiac branches of the sympathetic; r, plexus gulæ; o, celiac plexus of vagus; m, solar plexus; m', spleen; n, hepatic branches of vagus; II, scheme of the course of the depressor and accelerator nerves of the heart in the cat.

in the thyro-hyoid membrane, and divides beneath the mucosa in the pyriform sinus (p. 620) into a superior or epiglottic branch, distributed, as its name implies, both to the mucosa and to the subjacent tissues, and two or three inferior or pharyngo-laryngeal branches, distributed to the mucosa of the larynx and the neighbouring parts of the pharynx. Its lower pharyngeal branch communicates with the inferior laryngeal by a filament on the hinder surface of the *crico-arytenoideus posticus* muscle.

The **cervical cardiac** branches are two or three fine threads arising in the upper part of the neck, a little below the ganglion cervicale. The uppermost on each side communicates with a branch of the external laryngeal and accompanies it, descending into the thorax behind the carotid artery, where their ending on the right in the deep, on the left in the superficial cardiac plexus, has already been noted (p. 350). Depressor fibres probably ascend in it.

The **inferior or recurrent laryngeal** (fig. 681, 5) arises from the right vagus, where that nerve crosses the subclavian artery, and hooks round that vessel to ascend behind it. On the left, it similarly winds round the aorta to the left of the ductus arteriosus (§ 213). These nerves ascend in the groove between the trachea and œsophagus, behind the common carotid and the inferior thyroid arteries. They enter the pharynx below the lower margin of the *inferior constrictor* and break up into terminal laryngeal branches. At first this nerve passed directly to the larynx below the fourth aortic arch, but the change of relative position of parts in the course of growth has caused it to take a recurrent course, except when the fourth arch is obliterated (p. 556).

While winding below its artery, the inferior laryngeal nerve gives off *cardiac* (§ 218), and *communicating* branches to the lowest cervical sympathetic ganglion. In the lowest part of its ascending stage, it gives off superior œsophageal and superior tracheal branches. These branches form a plexus, beset with some minute ganglion cells in the muscular tissue of these tubes.

The terminal inferior laryngeal branches are two—an anterior, which supplies the *thyro-arytenoid* and *crico-arytenoideus lateralis* muscles, and sends upwards a branch to the epiglottic muscles; and a posterior, which supplies the muscles on the back of the larynx, conspicuously communicating with the superior laryngeal.

The muscles of vocalisation are innervated by fibres which the vagus receives from the accessorius, but it is probable that some motor filaments, independent of these, pass to the more purely respiratory muscular fibres of the trachea and larynx.

The inferior stages of the vagus have been described at pp. 348, 395, 460, and is shown in fig. 517.

488. THE ELEVENTH NERVE (fig. 681, 11), or accessorius Willisii, has been already seen (p. 529) within the cranium ascending from the spinal canal behind the ligamentum denticulatum, and should be again examined at this part of its course. Having entered the cranium it escapes through the jugular hole with the vagus. Its compound origin is elsewhere described, but its fibres combine

at their exit into a single cord. After its exit it divides into internal and external branches. The former, consisting of its upper fibres, joins the vagus, and has been therewith described; the latter consists of the lower or more purely cervical fibres, which, as they ascend in the spinal canal, are more or less connected with the hinder roots of the first and second spinal nerves.

This external branch after its exit descends at first in front of these on the outer side of the internal jugular vein, in front of the costal process of the atlas, and beneath the posterior belly of the *digastric*. It passes to the upper and inner edge of the *sterno-mastoid*, and enters that muscle below its upper fourth, traverses the second fourth, and emerges at the hinder border of that muscle about its mid-point (fig. 624). Here it crosses the supraclavicular triangle and passes beneath the outer edge of the *trapezius* muscle, in the deep surface of which it ends. Close to its origin it receives a fine twig from the ganglion cervicale, and in, or behind the *sterno-mastoid* it has a large and conspicuous communication with branches of the third cervical nerve; lower down, as it enters the *trapezius*, it receives branches both from the third and fourth cervical nerves, which terminate with it in the *trapezius* muscle (fig. 626).

489. THE CERVICAL SYMPATHETIC NERVE consists of a stem-cord, on which there are three ganglia (fig. 681). The **superior ganglion** is an

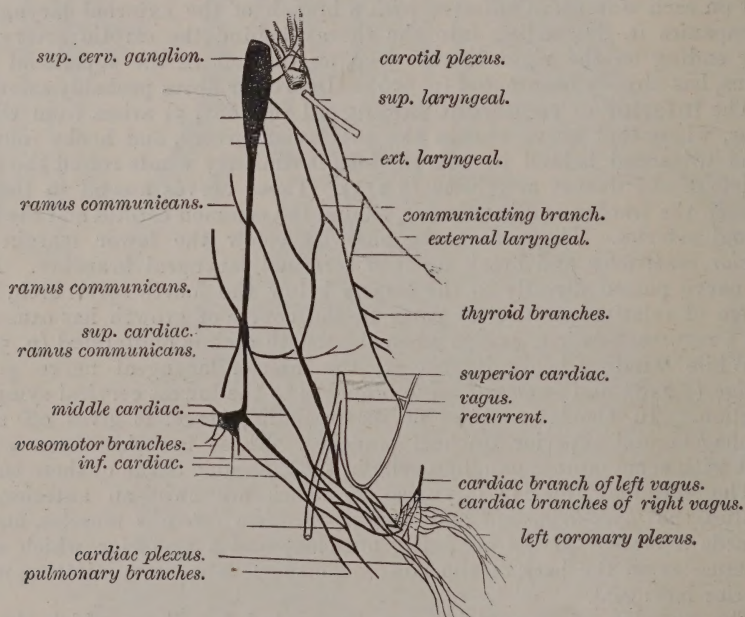


Fig. 682.—Scheme of the cervical sympathetic nerve and its branches.

elongated fusiform mass, 3 cm. long, sometimes marked by two or more constrictions, which lies internal to the vagus on the *rectus capitis anticus major*, and behind the carotid sheath, opposite the first, second, and third cervical vertebræ. It receives on its outer side four rami communicantes, derived from the four upper cervical nerves (fig. 626), and sends at least two twigs to the lower and one to the upper ganglion of the vagus. It is connected also by fine filaments, with Andersch's ganglion on the glosso-pharyngeal, and with the hypoglossal nerve. Above, it sends a strong, thick cord into the carotid canal, which will be traced with the second stage of the carotid artery; below, it tapers into

the cord which connects this ganglion to the second. From its anterior surface it gives off several, usually three, *external carotid branches*, which form a plexus around that artery and its branches. These branches are continued on the thyroid artery to the thyroid body. On the lingual artery they form a large plexus, in which ganglion cells are entangled. The plexus around the facial artery sends branches to the submaxillary gland and ganglion; and from the branches around the temporal, which enlarge into a distinct **superficial temporal ganglion**, branches pass to the parotid gland and to the auricular branch of the facial nerve. Through the branches which surround the middle meningeal, they are connected with the lacrymal nerve and otic ganglion; and similar plexuses surround the other arteries. A branch of the external carotid plexus terminates in the intercarotid body (fig. 678).

The pharyngeal branches of sympathetic are four or five, partly from the ganglion directly, partly from the external carotid plexus around the pharyngea ascendens artery, on which they sometimes form a small ganglion. They enter the pharyngeal plexus.

The **superior cardiac nerve** arises from the lower part of the ganglion, and descends on the longus colli muscle behind the carotid sheath. In the neck it receives other sympathetic filaments—a branch from the trunk of the vagus, one from the external laryngeal, and, still lower, one from the recurrent laryngeal. On the right it is smaller than the left, and lies in front of (rarely behind) the right subclavian artery, passing to the deep cardiac plexus; while on the left it crosses the arch of the aorta and ends in the cardiac ganglion and superficial plexus (p. 350).

The sympathetic cord descends from the first ganglion, behind the carotid sheath; and opposite the sixth cervical vertebra, as the cord crosses the inferior thyroid artery, it usually presents a minute, somewhat triangular, thickening, the **middle cervical ganglion**. This is joined by rami communicantes from the fifth and sixth cervical nerves, which emerge internal to the inner margin of the *scalenus anticus*, and gives off (1) *thyroid branches* around the inferior thyroid artery to the thyroid body, in connection with which there are some minute ganglia; (2) the large *middle cardiac nerve*. This last descends with the superior cardiac, often over the subclavian artery on the right, between the carotid and subclavian on the left (§ 218). The sympathetic cord descends from this ganglion in the form of two or more filaments, of which one descends in front of the subclavian artery, a second, shorter and thicker, behind it. The loop of union of these is the *ansa of Vieussens* (fig. 423, *ansa*).

The **inferior cervical ganglion** lies deeply at the lower part of the neck in the hollow between the transverse process of the seventh cervical vertebra and the neck of the first rib. It can be found most easily by dividing the subclavian artery and its superior intercostal branch. The latter lies directly external to, and the vertebral artery lies in front of, the ganglion. It receives rami communicantes from the seventh and eighth cervical nerves, and is joined by a band of ganglion substance and several thick nerve cords to the first dorsal ganglion. From the inferior ganglion arise (1) branches which form the plexus surrounding the subclavian artery and its branches; (2) separate similar branches from the very large plexus around the vertebral artery; and (3) the *inferior cardiac nerve*, which enters the deep cardiac plexus on each side.

490. BICHAT'S SECTION.—Dissection.—To display the deeper visceral structures in the neck, cut all these parts and the great vessels horizontally in front of the vertebral column at the level of the first rib. Draw these divided parts forwards, and, dissecting through the lax tissue which binds the back of the pharynx to the front of the spine, carry the separation up to the base of the skull, dividing the basi-cranial periosteum between the pharynx and the prevertebral muscles.

Extend the head forcibly backwards so as to bring the cut edge of the base of the skull to rest on the table, and with a broad-bladed chisel and a mallet cut through the basi-

occipital bone transversely. Turn now the head on one side, and divide the skull with a saw in a nearly coronal vertical plane, beginning outside, 1 centimetre behind the mastoid process, and carried inwards to the hinder limit of the jugular foramen. Turn the head on its opposite side and make a similar section, then, having completed the division by means of the chisel, the back of the skull and vertebral column are now separated from the face and pharyngeal region. It is more convenient now to finish the dissection of the former region, so the latter should be carefully wrapped up in cloths moistened with the preserving fluid and put away until the prevertebral dissection is finished.

491. PREVERTEBRAL REGION.—The lax areolar tissue which joined the post-pharyngeal fascia to the spine having been cleaned off, the prevertebral fascia and two groups of muscles are exposed—median and lateral. The median muscles are as follows:—

(1) **Longus colli** (fig. 683) consists of three imperfectly separable sets of muscular fascicles, a *vertical* nearest to the middle line, an *inferior oblique* arising with the vertical but separately inserted, and a *superior oblique* arising separately but inserted with the vertical. The vertical fibres arise tendinously

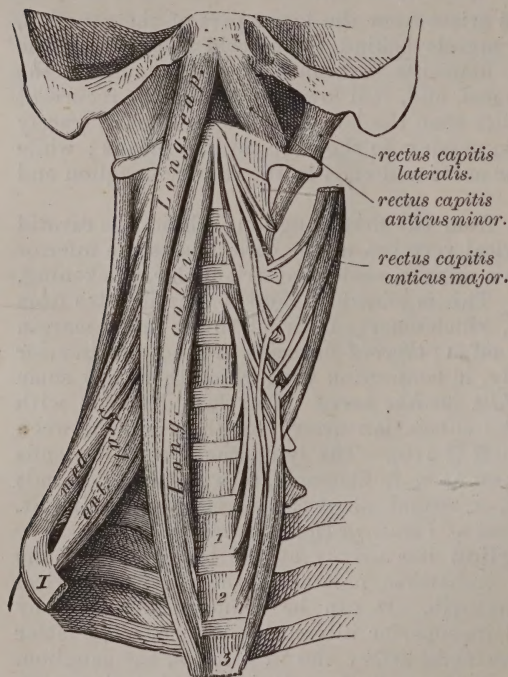


Fig. 683.—Dissection of deep muscles of the front of the neck.

cervical vertebræ, and is inserted fleshily with the vertical fibres into the anterior arch of the atlas and the two succeeding cervical bodies.

The slip which passes to the atlas is the most distinct, and can be artificially separated as a *longus atlantis* muscle. There is rarely any part attached to the costal process of the seventh cervical vertebra.

The longus colli is supplied by short metameric branches from each cervical nerve.

(2) **Rectus capitis anticus major** (*longus capitis*—fig. 683) is a specialised portion of the superior oblique fibres of the longus colli, which arises by four tendons from the costal processes of the second, third, fourth, and fifth cervical vertebræ, and is inserted into the basioccipital behind and outside the pharyngeal

from the rough lateral ridges on the bodies of the upper three dorsal and lower two cervical vertebræ, external to the anterior common spinous ligament. Ascending in a slightly arched manner with an internal concavity, the fibres are inserted, also by tendons, into the anterior tubercle of the atlas, and into the bodies of the second, third, and fourth cervical vertebræ, external to the anterior ligament. This is the largest part of the muscle.

The inferior oblique portion arises along with the vertical fibres from the upper three dorsal vertebræ, and is inserted into the costal processes of the sixth, fifth, and fourth cervical vertebræ.

The slip inserted into the sixth is strong and distinct at its insertion, and ascends in front of the vertebral artery, which it protects at its entry into the transverse process.

The superior portion arises from the costal processes of the second, third, fourth, and fifth

spine. It is supplied by branches of the first and second cervical nerves. Detach this from its insertion, and expose (3) the very small **rectus capitis anticus minor** muscle which lies beneath and external to it. This arises from the costal process of the atlas, and, ascending inwards, is inserted into the basi-occipital behind the last. (4) External to it is the **rectus capitis lateralis**, the topmost *cervical intercostal*, arising from the costal process of the atlas and inserted into the jugular process of the occipital bone.

(5) **The cervical intercostals**, or anterior intertransverse muscles, are thin slips passing between the successive costal processes and placed in front of the outgoing cervical nerves. They cover the vertebral artery.

These muscles unitedly flex the head and cervical column. When those of one side act they can lateralise the head.

The lateral muscles are three on each side.

Scalenus anticus arises by four slips from the costal processes of the third, fourth, fifth, and sixth cervical vertebræ; descending and tapering, it is inserted into the *scalene tubercle* on the margin of the first rib, having the subclavian vein in front of it and the subclavian artery behind it. Its inner edge is in contact with the outer margin of *longus colli*.

This is a specialised band of the cervical intercostal muscles, and bears traces, by numerous partial tendinous intersections, of its polymerism; it is supplied by branches of the third and fourth cervical nerves. The phrenic nerve descends on its anterior surface.

Scalenus medius, much larger and stronger, arises from the extremities of the transverse processes of all the cervical vertebræ except the first and last, and is inserted into a rough impression on the first rib behind the groove for the subclavian artery. The brachial plexus chiefly escapes between this and the next muscle.

This is also intercostal and polymeric, some portions of its upper slips being inserted into the slips of origin of their successors.

Scalenus posticus, smaller and less distinct, arises from the backs of the transverse processes of the two, seldom three lower cervical vertebræ, and is inserted into the second rib in front of the attachment of the *levator costæ*.

It is the modified cervical *levator costæ* muscle.

Being condensed muscles derived from several segments, the scalenes are very variable. They are elevators and fixers of the first and second rib, and thus act as respiratory muscles.

The second stage of the vertebral artery (§ 422) can now be more easily and completely dissected by removing the cervical intercostals, and dividing with the bone forceps the costal processes of the third, fourth, fifth, and sixth cervical vertebræ. The accompanying and enveloping plexus of veins should be noted, as well as its branches in this stage.

Having revised the deep muscles of the vertebral region, the intervertebral and vertebrocranial articulations should now be dissected (§§ 76, 79).

492. THE PHARYNX—Dissection.—Moderately distend the cavity of the pharynx through the mouth with cotton wadding soaked in spirit. Fasten the pharynx to a block so that its posterior side is exposed, and remove the loose connective tissue which covers this surface.

The pharynx, when thus prepared (fig. 684), appears as a somewhat oval musculo-membranous bag, about 10 cm. long, extending from the base of the skull to the cricoid cartilage opposite the fifth cervical vertebra; widest opposite the hyoid bone, tapering slightly upwards, more rapidly downwards. This shape is, however, artificial, as in life the cavity is a mere slit (fig. 641), the hinder and fore walls being for the most part nearly in apposition, except when food or air is passing. Posteriorly the pharynx is separated from the prevertebral muscles by the **prevertebral fascia**, which sheathes them, and by the stronger **post-pharyngeal fascia**, which is laterally attached to the sheaths of the vessels. On each side it is in contact with this sheath, and with the great cervical vessels. In front the pharynx communicates with the nose, mouth, and larynx.

Above, the pharyngeal wall is connected to the basioccipital, the internal pterygoid plate, the pterygo-mandibular ligament, and the lower jaw, in front to the hyoid bone, the thyroid and cricoid cartilages.

The wall of the pharynx consists of (1) the investing post-pharyngeal fascia, and the areolar layer beneath it, the backward continuation of the *bucco-pharyngeal fascia*, containing the large pharyngeal plexus of veins which collects the venous blood from all contiguous parts, and empties it chiefly into the pterygoid plexus, but in part, also, into two **descending pharyngeal veins**, which open into the internal jugular (p. 564).

(2) On removing these fascial layers, the muscular wall is exposed, and consists of two strata, one of circular fibres, the constrictors, and a deeper of

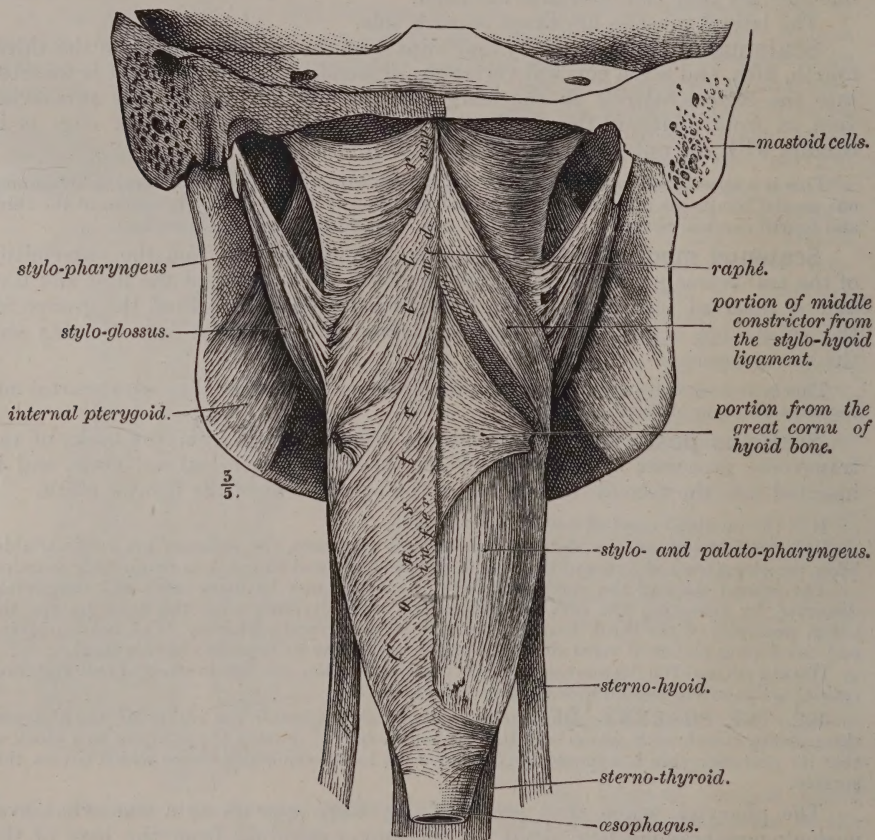


Fig. 684.—Posterior surface of pharynx dissected by the method of Bichat's section.

longitudinal. The circular fibres are in three planes which partly overlap each other from below upwards. These arise externally and pass backwards and inwards to be attached to the hinder middle line or **raphe** of the pharynx.

The **inferior constrictor** is the thickest and most superficial (fig. 684), and arises from a flat ridge on the side of the cricoid cartilage, and from the inferior cornu, oblique line or ligament, and superior tubercle of the thyroid cartilage. From this narrow origin, which is usually supplemented by fibres from the *crico-* and *sterno-thyroids*, its fibres expand backwards, the lowest

horizontally, the upper ascending steeply to be inserted into the raphé for nearly three-fourths of the whole length of the bag.

Its lower border overlaps the beginning of the œsophagus, receiving branches of the recurrent laryngeal nerve at the interspace. Above, it overlaps the *middle constrictor*, the interval between the two being on the level of the entrance of the superior laryngeal nerve into the thyro-hyoid space. The thyroid body and great vessels lie on each side, and it covers not only the next muscle but the *stylo-* and *palato-pharyngei*.

The **middle constrictor**, shown by raising and reflecting the upper edge of the last, is widely triangular, arising from the hinder and upper part of the thyro-hyal and cerato-hyal cornua and stylo-hyoid ligament. These parts are sometimes called respectively cerato-pharyngeus and chondro-pharyngeus. Its widely expanding fibres are inserted into the raphé, its upper fibres rising as high as the basioccipital, and its lower passing downwards to the lower end of the bag. Laterally the *middle constrictor* is in contact with the carotid sheath, and near its origin it lies beneath the lingual artery and *hyo-glossus* muscle, and is crossed by the superior laryngeal nerve.

By reflecting the upper edge of the *middle constrictor*, the insertion of the *stylo-pharyngeus* is brought into view, and its fibres can now be traced to the upper and hinder edge of the thyroid cartilage.

The *stylo-pharyngeus* muscle separates the *middle* from the **superior constrictor**, which can be fully exposed by removing the *internal pterygoid* muscle and the *middle constrictor*. It arises from the lower third of the hinder edge of the internal pterygoid plate, from the hamular process (*pterygo-pharyngeus*), from the pterygo-mandibular ligament, the hinder fifth of the mylo-hyoid ridge on the mandible (*mylo-pharyngeus*), and from the side of the tongue (*glosso-pharyngeus*). Its fibres unite into a continuous sheet, which curves inwards to be inserted into the pharyngeal spine of the basioccipital and into the upper part of the raphé.

The upper edge appears crescentic in shape, curving below the Eustachian tube and *levator palati* muscles. Between this margin and the base of the skull is a semilunar space on each side, the **sinus of Morgagni**, in which the underlying fibrous tissue is strong, and in which the *levator palati* can be seen projecting at each side. Outside this muscle lie the internal carotid artery, the glosso-pharyngeal, vagus, and sympathetic nerves, and on its anterior surface lie the *palato-pharyngeus* muscle and the tonsil. The *buccinator* is connected to it by the pterygo-mandibular ligament (§ 464).

On dividing the constrictors medially, and reflecting them from within outwards, the submucous tissue appears as a firm membrane above, the **pharyngeal aponeurosis**, but this thins and becomes indistinct below. It is attached to the periosteum of the basioccipital, to the apex of the petrous bone, and to the fibrous investment of the petro-occipital cartilage and Eustachian tube, as well as to the internal pterygoid plate. In the median line this membrane is strong at its attachment to the pharyngeal spine, and it forms the basis of the raphé of the pharynx.

In action, the constrictors compress the pharynx and act from above downwards.

493. CAVITY OF THE PHARYNX.—The pharynx is to be opened by a vertical median incision from the basioccipital to the level of the back of the cricoid cartilage, the basicranial attachment being divided transversely for 2 cm. on each side. Remove the bolus of cotton wool which distended the cavity, and wash the mucous surface with weak spirit. The cavity, as seen from behind, is divided by the plane of the soft palate into an upper or nasal region, the naso-pharynx, and a lower or oral region. Seven openings appear in the pharynx, two pairs above in the nasal region, the choanæ and Eustachian tubes, three single below, the fauces, the glottis, and the œsophagus.

The pharyngeal mucosa is continuous in front with that of the mouth and nose, laterally with that of the ear, and below with that of the œsophagus and larynx. Above, where it coats the occipital bone, it is dark brown, soft and spongy, and presents in the median line an irregular, flask-like pit, the **bursa pharyngea** (fig. 686, *), whose opening is usually narrow and directed downwards and forwards, its wider fundus pointing upwards towards the basicranial foramen. It is a pouch of mucous membrane which occupies the site of the continuation upwards of the pharyngeal tube, pinched off by the ingrowth of the parachordal cartilages, and thereby separated from the pituitary body above (p. 14). Around and below it on the posterior wall is a large continuous patch of lymphatic follicles, stretching across the upper and back part of the pharynx from side to side, and constituting the **pharyngeal tonsil**. It is not distinctly circumscribed, but occupies the space behind and between the Eustachian tubes on each side (fig. 686, 4), and extends to the roof of the cavity

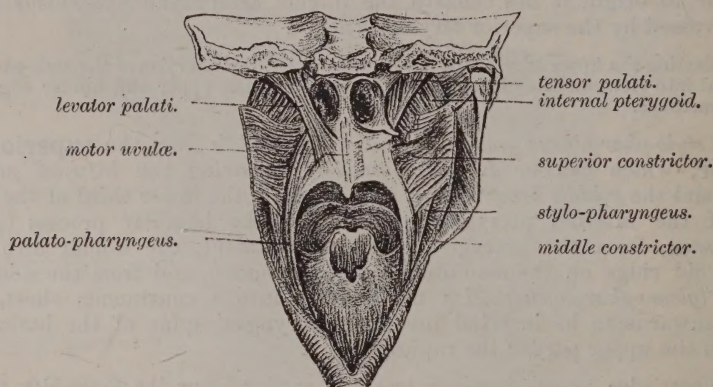


Fig. 685.—Cavity of the pharynx laid open from behind.

as far as the choanæ. This area is liable to tumefaction in catarrh, and produces the incapacity of nasal phonation consequent thereupon. This nasal area is lined by ciliated columnar epithelium.

Posteriorly, the mucosa is thinner, and below the pharyngeal tonsil the epithelium becomes stratified and scaly, like that of the mouth.

Laterally, and above, the mucous membrane is prolonged on each side into a pouch, the **pharyngeal recess** (fig. 686). These end opposite the tip of the petrous bone, and are the remains of the dorsal ends of the second post-oral visceral pouches, which were never perforate in the normal human embryo. External to these is the internal carotid, the dorsal artery of the second arch.

In front are the elliptical **choanæ** or openings of the posterior nares (fig. 685), 3 cm. high and 15 mm. across, with vertical long axes separated from each other by a thin vertical median septal membrane, prolonged back from the hinder edge of the vomer. Above, the mucosa of the choanæ is continued upon the lower surface of the basisphenoid; laterally, the mucosa is thin and firmly attached on the inner side of the internal pterygoid plate; below, they are bounded by the mucous membrane covering the upper and back edge of the palate process of the palatine bone, which is continuous therefrom on the nasal surface of the velum.

Through the opening can be seen the prominent hinder edge of the inferior turbinal bone, with the inferior meatus below it. Above, the middle turbinal bone projects between the middle meatus below and the superior meatus above.

The student should practise passing a catheter through the nose from the anterior nostril along the floor to the posterior naris, and should also determine the relation of the Eustachian tube thereto and practise passing a sound thereinto. The mucosa of the pharyngeal roof can be felt during life by the finger introduced by the mouth and turned upwards. The student should also practise posterior rhinoscopy on the body.

In the mucosa, on the lateral and hinder wall of the pharynx, are many small racemose glands, which, with the submucous tissue around them, make a distinct layer. These gradually become fewer and smaller below, and are sparse at the level of the mouth.

494. THE ISTHMUS FAUCIUM can be here seen on its hinder side, depending for its shape on the position of the soft palate.

In the fœtus before the fourth month the anterior pillar of the fauces is a sharp valve-like fold, the front boundary of a deep recess, which was the lower part of the primitive second post-oral cleft. The tonsil consists of adenoid tissue developed in the wall of this cleft. There is often a permanent trace of the lower part of this post-oral pouch in the form of a **supratonsillar fossa**. The secondary development of the inner longitudinal fibres of the *palato-pharyngeus*, in the floor of this fossa, has formed the posterior pillar of the fauces and separated the supratonsillar fossa from the recess of the pharynx above it. The greater relative development of the hinder than of the fore pillar of the fauces, despite the greater antiquity of the latter, is an illustration of the increased functional importance of these folds.

495. THE EUSTACHIAN TUBES, which convey air to the cavity of the tympanum, open on either side of the choanæ and opposite their lower half, on the level of the hinder border of the inferior turbinated bones. Each opening has a prominent rounded border above and behind, but slopes downwards and forwards with no projecting lower or front lip. From this the canal is directed at an angle of 45° upwards, as well as backwards and outwards. It passes between the two great palatine muscles—the *tensor palati* being external and in front; the *levator*, internal and behind. The latter muscle bulges beneath the mucosa and forms a convex eminence behind the opening of the Eustachian tube, as can be seen with the rhinoscopic mirror.

On removing the mucus covering of the border of the orifice the **Eustachian cartilage** is shown (fig. 763). This is an elongated triangular piece of white fibro-cartilage, folded on itself so as to guard the tube above and behind. It completes this boundary of the inner part of the tube, which lies in the groove between the petrosal and the ali-sphenoid, but the lower and anterior part is bounded by fibrous tissue

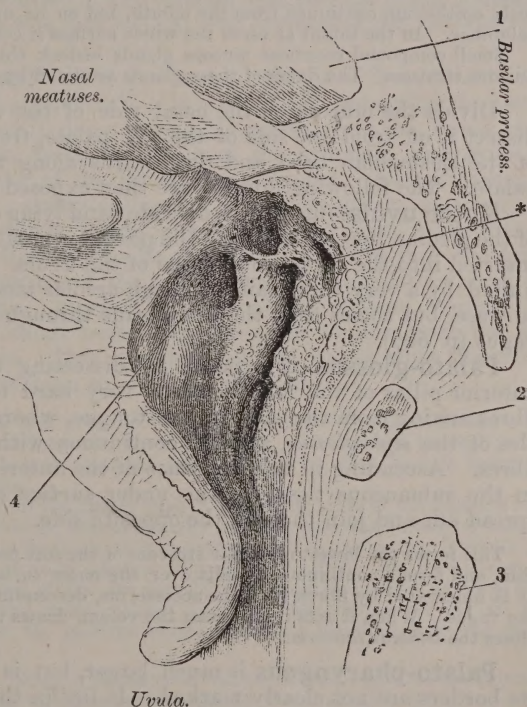


Fig. 686.—Mucous surface of the upper and outer angle of the nasopharynx—2, atlas; 3, axis.

only. The pharyngeal base of the cartilage fills the scaphoid fossa, and is fixed to the processus tubarius of the internal pterygoid plate.

The rest of this tube will be seen in the dissection of the ear (p. 691). The Eustachian tube is the modified remains of part of the first post-oral visceral cleft.

496. THE VELUM PALATI, or soft palate, has been already seen from the oral side and can now be dissected from behind. It constitutes an imperfect flap door between the mouth and pharynx. It is capable of being raised so as to shut off the nasal region and to open the isthmus faucium. This is its condition in swallowing, and in the phonation of all but nasal sounds (*n, g, m*, and the nasal vowel). The height to which it is raised in vocalisation varies, being highest in the pronunciation of *e*, lowest in the production of *u*, and relatively intermediate in that of *a* and *i*. In ordinary respiration it is pendent, and allows the passage of air from the larynx into the nasal region of the pharynx. Its plane is in front of that of the opening of the glottis, but in the normal throat is always much above its level (fig. 641).

The nasal surface of the velum is convex along its vertical axis and concave transversely; it presents a faint middle ridge, or *raphe veli*, descending to the uvula, marking the line along which the primitively separate lateral halves have coalesced.

The arrest of embryonic growth and consequent interference with this median union produces the condition of cleft soft palate which so often accompanies harelip. The nasal surface of the velum is covered for its lower half and free border in the adult with stratified scaly epithelium continued from the mouth, but on its upper half the epithelium is ciliated columnar. In the infant at birth the whole surface is covered with ciliated epithelium.

Small compound racemose mucous glands bedeck this surface, forming a complete submucous stratum. The ducts of these glands are lined by ciliated epithelium.

Divide the mucosa on the nasal side of the velum in the middle line, and dissect it off from one side of the soft palate, from thence upwards to the edge of the Eustachian tube, and downwards along the posterior half arch of the palate. The following muscles are then exposed:—

Motor uvulæ (fig. 685), a delicate band lying close to its fellow on either side of the median line, arising from the posterior nasal spine of the palatine bone, and inserted into the submucous tissue of the uvula. The two *motores* are medially united by a very thin plane of tough areolar tissue. Its nerve is very difficult to trace, but comes from the accessorius through the pharyngeal branch of the vagus (p. 607).

Palato-glossus is exposed by dissecting the mucous membrane of the anterior pillar of the fauces, but is very hard to isolate. It consists of pale fibres arising from the side of the tongue, where they interlace with the fascicles of the *stylo-glossus*, and are continuous with the hinder *transverse lingual* fibres. Ascending in the substance of the anterior pillar of the fauces, they end in the submucous tissue of the under surface of the velum, where its fibres spread out and join those of the opposite side.

This forms the lowest muscular stratum of the soft palate. The hindmost fibres are very thin, and form a continuous lamella over the outer surface of the tonsil (*amygdalo-glossus*). It is innervated by fibres from the accessorius, descending with the pharyngeal branches of the vagus. When it acts it depresses the velum, draws together the anterior pillars, and so closes the *isthmus faucium*.

Palato-pharyngeus is much larger, but is also with difficulty defined, as its borders are not clearly marked. It lies in the posterior pillar of the fauces, and in the pharyngeal wall behind this fold. At its upper part it consists of two strata, an upper and lower. The former is thin, and lies on the nasal side of the velum, where it expands under the mucosa, arising from the hinder margin of the palatine bone and palatine aponeurosis. The lower layer also arises from the palatine bone and from the oral side of the palatine aponeurosis.

The two layers unite at the margin of the posterior pillar and descend backwards, to be inserted internal to, and together with, the *stylo-glossus* into the hinder and upper border of the thyroid cartilage, and into the hinder part of the pharyngeal wall.

Two fine bundles of muscular fibres, accessory to the *palato-pharyngeus*, arise—one from the back, the other from the lowest part of the Eustachian cartilage. These become below blended with the rest of the muscle, of which they are only aberrant slips. They are sometimes artificially separated, and named *salpingo-pharyngei*. The two *palato-pharyngei* meet in the middle line in the velum, and again some straggling fibres below meet in the medio-dorsal line within the inferior constrictor. It is innervated through the pharyngeal plexus from the accessorius. It draws downwards the velum and upwards the pharynx in deglutition.

Levator palati, a thick definite band of muscle, arises from the lower and outer part of the Eustachian cartilage, and from the rough under side of the apex of the petrous bone in front of the carotid canal. It descends inwards and a little forwards, lying upon (as seen from behind) the upper border of the superior constrictor of the pharynx, and is inserted on the oral side of the *motor uvula* into the median line of the velum, overlying the origin of the inferior plane of the *palato-pharyngeus*.

It is supplied by a branch of the facial nerve conveyed to the muscle through the great superficial petrosal, Meckel's ganglion, and the posterior palatine nerve. At its upper part it receives a sheath from the pharyngeal aponeurosis, which isolates it from its neighbouring muscles. The ascending palatine artery (p. 562) branches upon the outer side of this sheath. Its fibres at their insertion unite with their fellows; both co-operating they raise the velum and draw it backwards.

Tensor palati lies anterior and external to the last, from which it is separated by the pharyngeal aponeurosis. It is shown by detaching the *levator* from its origin and reflecting it downwards. It arises from the linear outer margin of the scaphoid fossa, from the spine of the sphenoid, and from the outer surface and lower border of the Eustachian cartilage. As it descends its fibres converge, the hinder passing obliquely, the inner nearly vertically, to unite in a tendon which winds round the hamular process from without inwards, passing thence horizontally to be inserted expanding into the transverse ridge on the hinder surface of the palate plate of the palatine bone, and into the palatine aponeurosis. A patch of lax connective tissue, becoming in the adult an irregular but small bursa, separates the tendon from the concavity of the hamular process. This muscle raises and makes tense the velum, and aids in opening the Eustachian tube during deglutition.

Both these muscles are wider and much more oblique in the fœtus than in the adult. Its nerve is from the inferior maxillary division of the fifth, which passes through, and is supplemented by a second fine branch from the otic ganglion (p. 601), and it enters the muscle on its hinder and outer side.

Palatine aponeurosis.—From the hinder edge of the palate plate of the palatine bone, a strong elastic, but not very definite, fibrous lamella extends into the velum for which it forms a central skeleton. It rapidly thins as it descends, and is continuous laterally into the pharyngeal aponeurosis, and gives attachment to portions of all the palatine muscles.

The branches of the pharyngeal plexus are very hard to trace on account of their small size and softness. The larger and more distinct posterior palatine nerves can be seen descending on the hinder side of the palatine aponeurosis, and distributed to the glands and to the mucous membrane.

497. EMBRYOLOGY.—The pharynx is the modification of that region of the primitive vertebrate alimentary canal which was pierced laterally by the branchial clefts, and which joined the stomodæum (p. 15). The muscles and nerves of its wall are derived from those which originally are developed in the arches between these clefts, and the cavity has become shortened in the process of growth. In the human pharynx the visceral clefts behind the first post-oral slip are simple pouches, and do not extend to the outer surface in any stage of development.

The stomodæum joined the oral end of the mesenteron at about the fourteenth day, and

from its upper part is projected the **hypophysial pouch** of Rathke, which is prolonged through the base of the skull to form the anterior element of the hypophysis. Behind this the summit of the mesodæum projects as the **pouch of Seessel** (fig. 29, § 14).

The parts of the cavum oris and pharynx should now be reviewed as a whole in connection with the mechanism of the act of swallowing. The food having been reduced by mastication and insalivation to a pultaceous consistence, lies on the upper and back surface of the tongue. By a sudden spasmodic action of the elevators of the hyoid bone the tongue is forcibly raised, and, as the *mylo-hyoid* and the protractors of the tongue co-operate, the front of the tongue is forced against the roof of the closed mouth, and is thus made to fill the cavity, forcibly pressing the bolus of food through the isthmus faucium. The contraction of the palato-glossus draws together the two anterior pillars and closes this opening, thus preventing the return of the food. At the same time the velum is raised by the combined action of the *levator* and *tensor palati*, and so forms a fixed point from which the *palato-pharyngeus* can act, drawing the whole pharynx upwards and forwards over the projected mass of food, while, by the successive contractions of the two lower constrictors from above downwards, the last traces of the food are driven down into the œsophagus.

No food can, in normal swallowing, enter the glottis, as the aperture is forcibly closed. Indeed, so much is the opening of the glottis sheltered in swallowing by the protraction of the larynx and the dorsal bulge of the tongue, that it is probable the bolus scarcely touches the epiglottis.

The contractions of the pharyngeal muscles in swallowing succeed each other with such rapidity as to be almost simultaneous. They are really successive, the various layers contracting in the order in which they lie from within and above downwards and outwards, and in the need for this condition of action lies the cause of the arrangement of the muscular lamellæ.

The action of the pharyngeal muscles on the Eustachian tube is also noteworthy, while there is always a chink of the tube open, its lumen is perceptibly widened by the tension, during swallowing, of the pharyngeal muscles attached to it. It has been supposed, but without sufficient reason, that the bulge of the contracted belly of the *levator palati* diminishes the calibre of the opening of the tube.

498. OPENING OF THE GLOTTIS (fig. 687).—The upper opening of the larynx appears as a triangular aperture, whose plane is nearly vertical in the

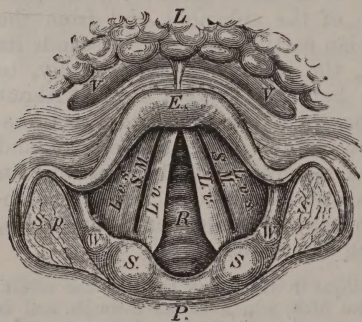


Fig. 687.—Opening of the glottis, as seen from above—*E*, epiglottis; *L*, tongue; *V*, glosso-epiglottic pouch; *W*, cartilage of Wrisberg in the ary-epiglottic fold; *S*, cartilage of Santorini on the summit of the arytenoid; *P*, pharynx, behind the interarytenoid notch; *S.p*, sinus pyriformis; *L.v*, true vocal chord; *S.M*, false chord; *L.s*, ary-epiglottic membrane; *R*, rima glottidis.

living throat. It is bounded above and in front by the projecting portion of the epiglottis, the sides are formed by the aryteno-epiglottidean folds, and the apex below and behind is at the interarytenoid notch. The mucosa continued backwards from the tongue on the epiglottis makes medially the **frænum epiglottidis**, on each side of which is the **vallecula**, bounded laterally by the **lateral glosso-epiglottic folds**.

The free edge of each **aryteno-epiglottidean fold** is directed backwards and a little upwards. It presents two thickened areas, one at the summit of the arytenoid cartilage, where it contains the cornicular cartilage, and a second a little above and in front, containing the cuneiform cartilage. Outside this fold is a shallow fossa on each side, the **sinus pyriformis**, lined by mucous membrane, and bounded externally by the upper and back part of the thyroid ala.

This is the remains of the third post-oral visceral pouch which was imperforate in the human fetus, and corresponds to the interval between the third arch, in which the thyrohyal cornu develops, and the fourth arch, in which the upper edge of the thyroid forms. The hinder limit of the laryngeal opening is the narrow **interarytenoid notch**.

Behind this the pharynx narrows to become the œsophagus at the level of the back of the cricoid cartilage. This is the narrowest part of the bag.

Above it on each side there has been seen, but very rarely, a slight lateral widening on each side the rudiment of the fourth branchial pouch, one of which may become pathologically enlarged. The side of the epiglottis is connected to the posterior pillar of the fauces by a fold of mucous membrane, the **pharyngo-epiglottic fold**, beneath which is a weak fibrous fold of the pharyngeal submucous tissue, the **pharyngo-epiglottic ligament**, attached above to the lower border of the Eustachian cartilage, and below to the side of the epiglottis.

The position of the opening of the glottis varies. In rest it is opposite the intervertebral space, between the third and fourth vertebræ; in forced respiration it descends to the fourth; in deglutition it is raised to the level of the top of the third and drawn forwards. Extension of the head backwards puts all the structures of the larynx on the stretch and lengthens the tube, but its upper end sinks to the level of the fourth vertebra.

499. THE LARYNX is the upper part of the respiratory tube, which is set apart to act as the organ of voice. Its framework consists of five larger cartilages (two median and one pair of true cartilages, and one elastic fibro-cartilage), and two pairs of rudimental cartilages. These are united by ligaments to form a short tube, which opens above into the pharynx and below into the trachea. It is desirable to examine a set of cleaned cartilages prior to the dissection of the recent larynx.

500. THE THYROID CARTILAGE, which covers two-thirds of the front and sides of the tube, consists of two flattish quadrilateral **alæ**, united medially at an angle of 80° , and projecting prominently forwards as the **pomum Adami**. Each ala has a free hind margin placed nearly vertically, but diverging a little from its fellow above, and prolonged upwards into a blunt cylindroid process, the **superior cornu**, whose summit is tied to the great cornu of the hyoid bone by a **posterior thyro-hyoid ligament**. Into this hinder edge parts of the *stylo-* and *palato-pharyngei* muscles are inserted. Below, this border is prolonged downwards and forwards into a curved cylindroid **inferior cornu**, shorter than the upper, which articulates with the outer side of the cricoid cartilage.

The upper border of the thyroid cartilage is depressed into a bay in front of the cornu and then rises into a sinuous convexity, dipping again in front to form the side of the **great median notch**, whose everted lips constitute the most prominent part of the pomum. The lower border is also notched in front of the inferior cornu and extends sinuously forwards, having two small downward projections—one in front of the posterior notch, the **inferior marginal tubercle**; the other where it joins its fellow medially. The anterior or **isthmie border**, where the one ala joins its fellow, is the shortest, it projects forwards above, is depressed medially, and again projects, but more slightly, below.

The outer face of the ala is smooth for its front and upper three-fourths, but is crossed obliquely by a faint line, which starts from the **superior tubercle**, below the fundus of the superior notch, and descends forwards to the inferior marginal tubercle on the lower border. This line is sometimes represented by a fibrous band stretched between the tubercles, and into this line or band the *sterno-thyroid* is inserted; and from it the *thyro-hyoid* arises, while the *inferior constrictor* arises from the ala behind it (fig. 124).

The inner surface of the thyroid ala is smooth, concave, and covered by mucous membrane in the sinus pyriformis.

Each ala is broader than high (7 : 5), and structurally consists of three parts—two lateral, of ordinary hyaline cartilage, and a middle, wherein the cartilage cells are smaller and closer. This middle area is isolated by planes of dense hyaline substance.

The hinder surface of the median angle at its lower part is depressed into

a small pit, the **median thyroid fossa**, into which the stalk of the epiglottis, the *thyro-arytenoid* muscles, and the true vocal cords are attached.

501. THE CRICOID CARTILAGE (figs. 688, 689, 670) is compared to a signet ring in shape, and completely engirdles the larynx; it is rounded and low in front, but rises behind into a quadrate hinder plate, divided by a median crest into two lateral muscular areas, which give rise to the *posterior crico-arytenoid* muscles. Outside this are two tubercles, one on either side, with which the inferior cornua of the thyroid cartilage articulate.

The superior border slopes from behind downwards and forwards, presenting a large median upward-directed concavity beneath the thyroid cartilage. At the upper margins of the hinder quadrate area on each side the cricoid presents a convex, oblique, oval

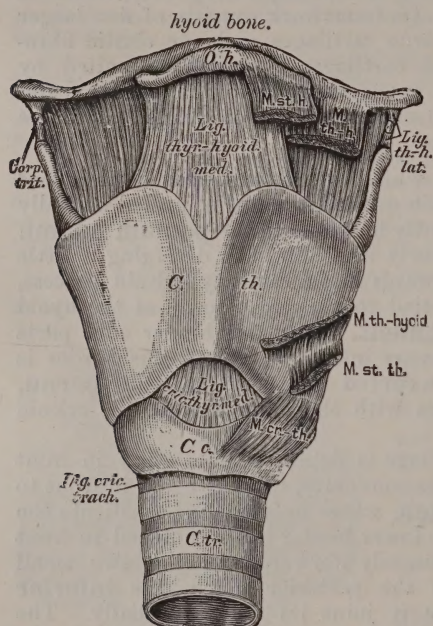


Fig. 688.—Front view of the cartilages and ligaments of the larynx—*O.h.*, basihyal; *st.h.*, sterno-hyoid; *st.th.*, sterno-thyroid; *th.h.*, thyro-hyoid; *C.th.*, thyroid cartilage; *C.c.*, cricoid cartilage.

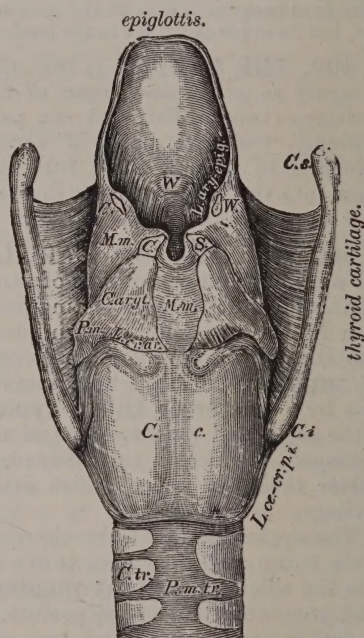


Fig. 689.—Posterior view of the cartilages and ligaments of the larynx—*C.s.*, superior cornu of thyroid; *W.*, cuneiform cartilage of Wrisberg; *S.*, corniculum of Santorini; *M.m.*, interarytenoid membrane; *M.m.*, aryteno-epiglottidean membrane; *P.m.*, muscular process of arytenoid; *W.*, prominent base of epiglottis; *C.c.*, cricoid cartilage; *C.tr.*, tracheal rings.

articular surface, directed upwards and outwards to bear the arytenoid cartilage. In front of this is a thickish, rather everted edge, which gives origin to the *crico-arytenoideus lateralis*. Internally, the cricoid is lined by the laryngeal mucosa all round, and externally it gives attachment on each side of its anterior surface and upper border, in front of the crico-thyroid articulation, to the *crico-thyroid* muscle.

The **crico-thyroid joints** are surrounded by capsular ligaments of radiating fibres, and each contains a synovial membrane. They allow the cricoid to glide upon the inferior cornua of the thyroid around the transverse axis, passing through the two joints; and it also permits a slight amount of

slide of the cricoid upwards and backwards. Between these joints the lower border of the thyroid is tied to the cricoid by a strong elastic **crico-thyroid membrane**. This is depressed and thin laterally where it is attached to the inner margin of the cricoid, close to the mucous membrane; but medially it forms a strong triangular plate, chiefly of elastic fibres, usually pierced by a median hole; it is crossed, near the thyroid attachment, by the crico-thyroid artery. It is this membrane that is cut through in the operation of laryngotomy.

The thyroid cartilage is tied above to the *upper* and *hinder* margin of the hyoid bone by a **thyro-hyoid membrane**. This chiefly consists of elastic fibres, and stretches from side to side. Above the superior lateral notch in the thyroid cartilage it is pierced by the superior laryngeal nerve and artery; behind which, the cornual attachment of the membrane is rounded and cord-like (the posterior thyro-hyoid ligament). In this hinder cord there is usually a small cartilage in shape and size like a grain of wheat, this is called the **triticeal cartilage** (fig. 688, *Corp. trit.*). The upper border of the thyroid cartilage during deglutition ascends behind the hollowed back of the basihyal, from which it is often (in 65 per cent.) separated by a bursa, which allows of free relative motion.

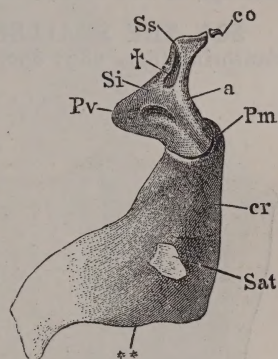


Fig. 690.—Side view of cricoid and left arytenoid cartilage—co, corniculum; cr, cricoid cartilage; a, arytenoid cartilage; Pm, muscular process; Pv, vocal process; Sat, surface for articulating with inferior cornu of thyroid; Ss, superior spine of vocal border; Si, inferior spine of vocal border; **, inferior tubercle of lower margin; †, sulcus externus.

502. THE TWO ARYTENOID CARTILAGES

(figs. 689, 690) are symmetrical, placed on the upper and back edge of the cricoid, and when taken together in the larynx of a sheep or dog, they form a groove like the mouth of a pitcher, hence the name. Each arytenoid cartilage is an irregular three-sided pyramid. Its apex above becomes fibrous and curves backwards and inwards to join the corniculum; its base below is obliquely grooved, and sits on the back of the cricoid. Its hinder surface is concave and is filled in the recent state by the *arytenoideus proprius* muscle. Its external surface is convex and gives attachment to the *thyro-arytenoid* muscle. Its narrow inner surface is smooth, covered by mucous membrane, and directed towards the corresponding surface of its fellow. The base presents three angles, an outer thick **muscular angle**, to whose hinder surface the *posterior crico-arytenoid* is attached, to whose front surface the *lateral crico-arytenoid* is attached. The anterior angle is the **vocal process**, and gives attachment to the true vocal chord; the posterior internal angle is tied to its fellow and to the cricoid by a **transverse ligament**.

503. THE EPIGLOTTIS (fig. 689) is a leaf-like plate of yellow reticular fibro-cartilage placed medially and in the coronal plane, attached by a narrow foot-stalk below to the median thyroid fossa. Its hinder surface is free, and clad with mucous membrane for its whole extent, and projects backwards at about its middle point into a convexity, the **pulvinar** (fig. 689, *W*), above which its free upper portion is curved forwards. This surface is, for the most part, concave transversely and convex vertically. Its lateral margins give attachment below to the aryteno-epiglottidean folds and are free for a short distance above. The front surface is fixed below by fibrous tissue to the thyroid cartilage; above this, a tough, elastic, areolar and fatty mass, the

periglottis, ties its front surface to the back of the thyro-hyoid membrane. The middle portion of the upper border of this periglottis is elastic, and constitutes the **hyo-epiglottic ligament**. Above this a thin, sagittally-placed elastic fold attaches it medially to the base of the tongue, enclosed in the sharp median frænum epiglottidis. The other mucous reflections from the epiglottis have been already noted.

To the margin between the anterior and posterior surfaces the **aryteno-epiglottic membrane** is attached.

The body of the arytenoid is of hyaline cartilage, its apical process becomes white fibro-cartilage, and the vocal process becomes elastic fibro-cartilage.

504. THE SMALLER CARTILAGES.—The **cornicula** or cartilages of Santorini (figs. 689; 690, co) are minute nodules of elastic fibro-cartilage of a pale yellowish colour, fixed by white fibrous tissue to the apex of the arytenoid and embedded in the hinder attachment of the aryteno-epiglottic membrane.

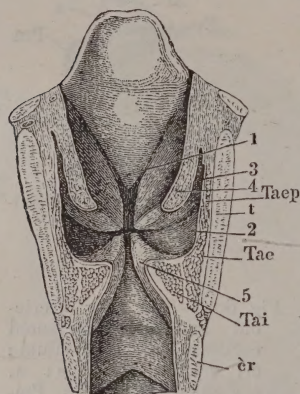


Fig. 691.—Vertical coronal section of larynx—1, stalk of epiglottis; 2, upper surface of true chord forming floor of the ventricle of the larynx; 3, outer wall of sacculus of Morgagni; 4, false vocal chord; 5, true vocal chord; Taep, thyro-ary-epiglottic muscle in section; Tac, external thyro-arytenoid muscle; Tai, internal thyro-arytenoid; cr', cricoid cartilage.

The **cuneiform**, or cartilages of Wrisberg, are still smaller, elongated and obconical streaks of elastic fibro-cartilage in the aryteno-epiglottic membrane, surrounded by a fringe of minute mucous glands, and making a slight thickening on the membrane.

The **crico-arytenoid articulation** is a peculiar condylarthrosis in which the concavity of the arytenoid surface has its long axis sagittally disposed, while the convexity of the cricoid is coronally prolonged. The two surfaces can never, therefore, thoroughly cover each other. The joint is surrounded by a thin, capsular ligament, whose fibres are specially strong laterally, and are connected medially with the *interarytenoid band*, where they are often specialised into an internal crico-arytenoid ligament. Enclosed in the capsule is a loose synovial membrane. The motions permitted in this joint are (1) rotation of the arytenoid around a vertical axis, which is parallel and very close to its inner surface; (2) gliding motions forwards and inwards, or backwards and outwards. The former motion is associated with rotation inwards of the vocal

process, while gliding outwards is associated with its rotation outwards.

505. THE INTERIOR OF THE LARYNX (fig. 687), as viewed from above, or in coronal section (fig. 691), is divisible into three regions. On each side the mucous investment of the aryteno-epiglottic membrane appears to end below in a crescentic margin with a downward concavity, this margin is called the **false vocal chord** (fig. 691, 4). Below this on each side a prominent fold appears stretched from the vocal process of the arytenoid forwards to the sides of the middle thyroid fossa, these are the **true vocal chords** (fig. 691, 5). Between the true vocal chords the cavity of the larynx is diminished to a narrow chink which is called the **rima glottidis**. On each side there is a recess, the **ventricle of the larynx**, between the false vocal chords above and the true chords below, giving the latter free space within which they can vibrate. Below the true vocal chords the lumen widens, and

from being a sagittally elongated, narrow chink at the rima, becomes nearly circular at the lower margin of the cricoid cartilage, hence this portion of the cavity is somewhat wedge-shaped.

There is, therefore, a *suprarimal*, a *rimal*, and an *infrarimal* area, whereof the middle is the most important.

The **suprarimal area** consists of two parts—(1) the *vestibular*, which extends from the pharyngeal opening of the larynx to the plane of the false chords. It narrows from above downwards, and its wall is much lower behind than in front. This space varies only by the altered position of the epiglottis in swallowing.

(2) The *ventricular area* consists of the two laryngeal ventricles (fig. 691, 4) and the part of the median tube between them. The false chords which project above the ventricles are soft and not capable of being made quite tense. They are farther apart than the true chords. Each ventricle extends laterally nearly as far outwards as the thyroid ala, and it is prolonged upwards and forwards into a narrow recess, the **laryngeal saccule** (fig. 691), which ascends outside the front edge of the false chords at the side of the epiglottis for a variable distance, usually about 5 mm.

The **rima glottidis** (fig. 687) is a narrow chink, bounded on each side by the inner edges of the true vocal chords, and by the interval between the inner surfaces of the two arytenoid cartilages; in front, it narrows and ends at the

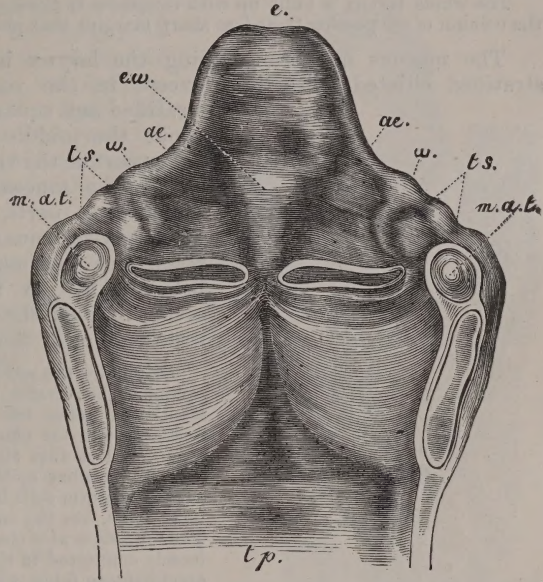


Fig. 692.—Interior of larynx, shown by a vertical division of its hinder wall and the separation of its sides—*e*, epiglottis; *ae*, aryteno-epiglottic fold; *ew*, pulvinar; *w*, cuneiform cartilage; *ts*, corniculum of Santorini; *m.a.t.*, arytenoideus proprius; *tp*, trachea.

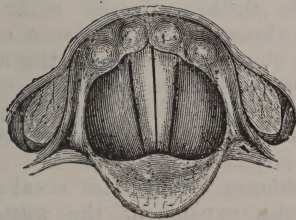


Fig. 693.—Laryngoscopic appearance of the true vocal chords during the production of a high note.

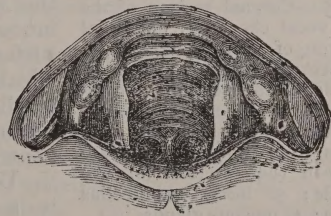


Fig. 694.—Laryngoscopic view of the vocal chords opened to their widest extent, showing the trachea to its bifurcation.

back of the thyroid; behind, it is closed by the mucous membrane reflected from arytenoid to arytenoid on the front of the **arytenoid** muscle. From the dual nature of its lateral boundaries, it presents two parts, an anterior

interchordal or vocal area, the longer and narrower portion, and a posterior **interarytenoid** or respiratory area, shorter and wider. In ordinary breathing (fig. 698 with the arytenoid cartilages at I, I) the vocal area is an elongated triangle with its base backwards, and the respiratory area has parallel sides. The vocal chords may be made tense or relaxed by muscular action; the rima may also be dilated (fig. 694) or contracted (fig. 693).

The whole larynx is built up with reference to these chords, as it is by the vibration of the column of air passing their free sharp margins that phonation is caused.

The mucous membrane lining the larynx is thin, pale, and clad with stratified ciliated epithelium, except in the vestibular region, where it is stratified and squamous, the cilia stopping short about the middle of the epiglottis and at the lower part of the ventricle. Upon the true vocal chords the mucosa is closely adherent to the underlying parts, and the epithelium consists of closely-set squamous cells along the marginal strip, but becomes ciliated again above and below this. A few goblet cells are found scattered over the whole area. The epithelium rests on a clear thin basement layer.

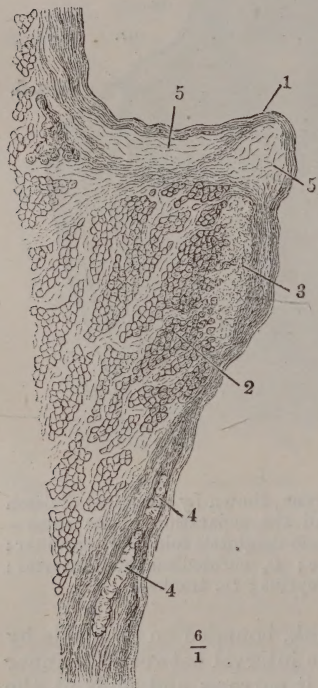


Fig. 695.—Coronal section of the true vocal chord—1, epithelial covering of its free sharp edge; 2, internal thyro-arytenoid muscle in cross-section; 3, compact elastic inferior thyro-arytenoid ligament sending processes from its outer surface between the fasciculi of the muscle; 5, looser submucous tissue; 4, mucous glands.

Originally the whole epithelium was ciliated, but the squamous conversion often affects not only the above-mentioned areas, but also extends to others, forming insular squamous patches in the midst of the ciliated area. Where this stratified epithelium is found there are also peculiar epithelial nerve endings, composed of curved fusiform cells in clusters, somewhat like modified taste buds, but the nervous element is not very clear. The mucosa is also closely tied to the epiglottis, but is loosely connected to the underlying parts in the aryteno-epiglottidean folds, whose loose areolar submucous layer is liable to oedema. The submucous tissue throughout the whole larynx is rich in elastic fibres.

Mucous glands are thickly strewn in the whole surface except on the true vocal chords. A row of these is disposed along the front margin of the arytenoid cartilage in the aryteno-epiglottidean fold. A second row borders the cuneiform cartilage, and a third series is enclosed in the false vocal chord. The back of the epiglottis is thickly covered with small mucous glands whose ducts can be seen on the surface. These glands fill some of the areolae which are so conspicuous on the surface of this cartilage. There are about forty large compound racemose mucous glands in the wall of the ventricle of the larynx.

Under the mucosa of the false vocal chord is a thin fibrous expansion, the **superior thyro-arytenoid ligament**, passing from the edge of the middle thyroid fossa to the arytenoid. Scattered fibres continuous therewith expand outwards into the wall of the sacculus laryngis and of the ventricle, and upwards into the aryteno-epiglottidean fold. Under and closely tied to the firm, thin *membrana propria* of the true vocal chords is the **inferior thyro-arytenoid ligament** (fig. 695, 5); this is a fine-fibred elastic ligament, whose inner sharp free edge is the basis of the true vocal chord. This shades

off externally, and becomes continuous above with the superior ligament in the wall of the ventricle; downwards it becomes lost in the submucous tissue of the infrarimal region; much of its lateral border is directly continuous into the lateral crico-thyroid membrane.

506. THE MUSCLES which act on the larynx and alter the condition of the rima, may be divided into two sets—(1) *extrinsic*, which are attached to the larynx from parts outside it; and (2) *intrinsic*, which pass from one part of the larynx to another. The extrinsic are the *sterno-thyroid* (§ 417) and *thyro-hyoid* (§ 417), the *inferior pharyngeal constrictor* (§ 492), the *stylo-* and *palato-pharyngeus* (§ 483) muscles, and indirectly the *sterno-hyoid*, *omo-hyoid*, and other hyoidean muscles. These serve to fix the hyoid

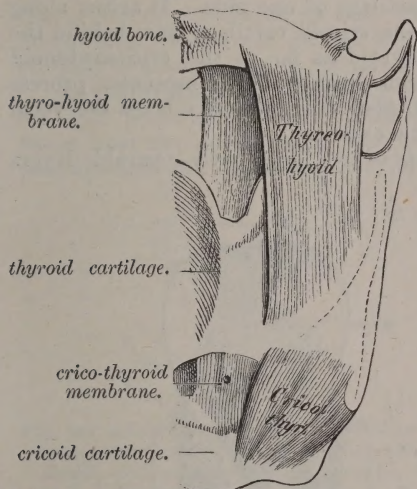


Fig. 696.—Muscles on the anterior surface of the larynx.

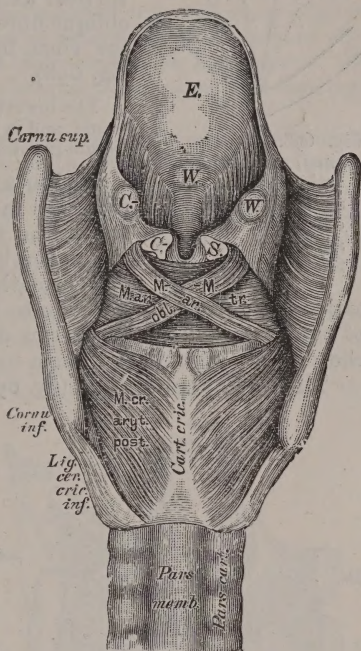


Fig. 697.—Dissection of the muscles of the larynx from behind—*E*, epiglottis; *W*, pulvinar; *C.W*, cartilages of Wrisberg; *C.S*, cartilages of Santorini; *Lig. cer. cric.*, inferior band of capsule of the lateral crico-thyroid joint.

bone and the thyroid cartilage, so that the intrinsic muscles can act therefrom.

The intrinsic muscles are the following:—

1. **Crico-thyroid** (fig. 696) arises from the front and side of the cricoid cartilage, and is inserted into the lower border of the thyroid cartilage and into the front edge of its inferior cornu. Medially the two muscles are separated by an interspace corresponding to the middle area of the crico-thyroid membrane. The muscle consists of upwardly diverging fibres, those inserted into the cornu being horizontal and often differentiated from the oblique fibres which pass into the lower margin of the cartilage. This muscle is supplied by the external laryngeal nerve (fig. 629, 1L). When its oblique fibres act alone they draw the cricoid backwards and upwards, rotating it around the crico-thyroid coronal axis; the horizontal fibres simply retract the cricoid, and hence both portions of the muscle in different ways make tense the vocal chords. This may be regarded as the coarse adjustment of the chords. The fine adjustment for phonation is produced by the vocal fibres of the *thyro-arytenoideus*.

2. **Crico-arytenoideus posticus** (fig. 697) lies behind, and covers the flat

area on the posterior surface of the cricoid cartilage. Each muscle arises from the lateral quadrangle area on the cricoid on each side of the median posterior ridge. Its fibres, converging, are inserted into the outer angle of the arytenoid cartilage. This muscle is also in process of differentiation and segmentation; its upper horizontal fibres, which rotate the arytenoid around its vertical axis, being more or less separate from the lower oblique fibres, which cause it to glide. This muscle dilates the rima by drawing the arytenoid cartilage outwards (fig. 698).

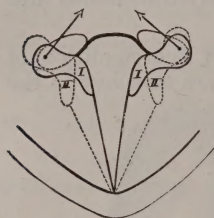


Fig. 698.—Scheme of rima, showing the action of the crico-arytenoideus posterior, which draws the arytenoid cartilages from I, I to II, II.

The lowest slip of this muscle not uncommonly misses the arytenoid, and is inserted into the inferior cornu of the thyroid cartilage (*kerato-cricoideus*).

Crico-arytenoideus lateralis (fig. 699), smaller than the last, is shown by detaching and removing the ala of the thyroid cartilage of one side. It arises along the upper border of the cricoid cartilage from behind the origin of the crico-thyroid as far as the crico-arytenoid articulation; it is inserted into the anterior surface of the muscular process of the arytenoid, which it can draw forwards. This muscle relaxes the vocal chords and approximates them to some little extent.

Thyro-arytenoideus (fig. 699) consists of two imperfectly separable layers

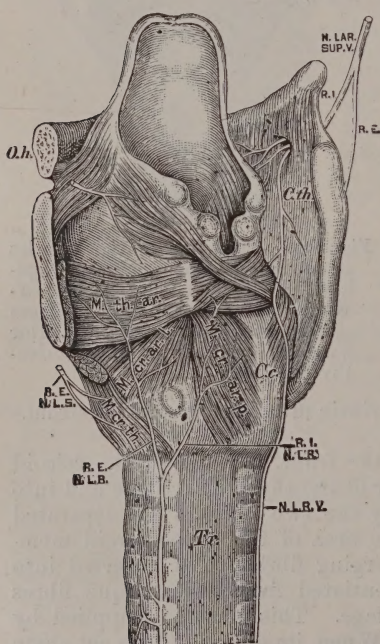


Fig. 699.—Muscles of the lateral aspect of the larynx, shown by removing one ala of the thyroid cartilage.

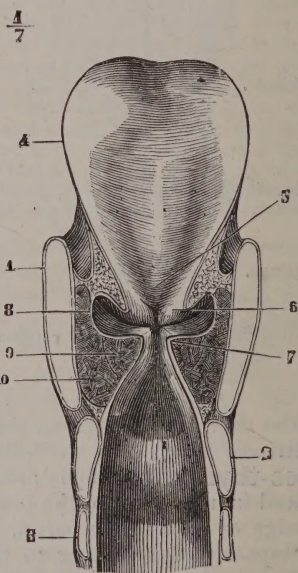


Fig. 700.—Coronal section of larynx directly in front of the vocal process of the arytenoid—1, thyroid cartilage; 2, cricoid cartilage; 3, first tracheal ring; 4, epiglottis; 5, pulvinar; 6, false vocal chord; 7, true vocal chord; 8, external thyro-arytenoid muscle; 9, internal thyro-arytenoid; 10, crico-arytenoideus lateralis.

—(1) *Thyro-arytenoideus externus* (shown in coronal section in fig. 700, 8), which arises within the thyroid ala on each side, from the thyroid cartilage and crico-

thyroid membrane; passing backwards it is inserted partly by transverse fibres into the arytenoid cartilage, partly by oblique fibres into the aryteno-epiglottidean fold, into the outer wall of the laryngeal ventricle, and by a separate band into the epiglottis. The latter slip is sometimes called *thyro-epiglotticus*.

The inner portion (fig. 700, 9) arises from the sides of the middle thyroid fossa and from the anterior attachment of the vocal chords. The fibres pass backwards in the substance of the chord to be inserted into the outer edge of the vocal process and the lower end of the outer aspect of the arytenoid cartilage. There are also fibres arising from the thyro-arytenoid ligament in the vocal chord in several sets, which are attached behind to the arytenoid cartilage (*aryteno-vocales*).

A series of oblique fibres, constituting a second portion of this subdivision, arises from the outer surface of the lateral half of the crico-thyroid membrane; these ascend as a thin scattered layer over the ventricle, and are inserted into the mucous membrane of the false vocal chord. These various portions rotate the arytenoid cartilages, so that the *processi vocales* are turned inwards and downwards; the vocal chords are consequently approximated, and the rima reduced to a long slit, the position necessary for phonation (fig. 701).

Arytenoideus Proprius (fig. 697).—Between the two arytenoid cartilages on their posterior side is a thick muscular sheet, which arises (I) by oblique fibres from the inferior and outer angle of the arytenoid cartilages. Its fibres pass upwards and inwards across the middle line, decussating their fellows of the

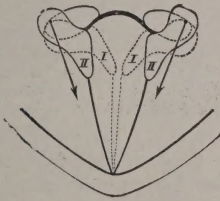


Fig. 701.—Scheme of action of the thyro-arytenoid muscles, drawing the vocal chords and vocal processes from II, II to I, I.

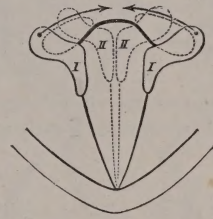


Fig. 702.—Scheme of rima, showing the action of the arytenoideus proprius muscle, drawing the arytenoid cartilage from the neutral position I, I to the position II, II.

opposite side, and are attached partly to the summits of the opposite arytenoid, but some of them are continued into the opposite aryteno-epiglottidean fold to the lateral margin of the epiglottis (fig. 699); hence these oblique fibres are often described as *aryteno-epiglottideus*, but not more than one-tenth of the fibres continue so far.

(2) The *arytenoideus proprius*, beneath these, consists of transverse fibres passing from one arytenoid to its fellow.

When these muscles act they make tense the vocal chords, and approximate the apices of the arytenoid cartilage, rotating them on their vertical axes. They thus close the respiratory area of the glottis, leaving the vocal area as the only passage for the expiratory current. This is the usual preliminary to phonation.

Nerves of Larynx.—The superior and inferior laryngeal nerves have been already described (§ 487), and should now be traced. The lingual aspect of the epiglottis is supplied by filaments of the glosso-pharyngeal nerve (§ 486), the laryngeal surface by the superior laryngeal (fig. 699), whose branches end in a close-meshed plexus beneath the thick epithelium and subepithelial layer, and are beset with ganglion cells, and end in free points, in taste-buds, and end-bulbs. The disposition of the nerves is somewhat similarly plexiform, but

without any taste-buds on the false vocal chords; but nerves are sparse and fine on the true chords. The arteries of the larynx from the superior (§ 438) and inferior thyroid (§ 423) have also been described, and can now be followed to their distributions. The capillaries form a close network in the submucous tissue over the whole surface. The lymphatics are few, and accompany the veins which pass along with the arteries; they end in the deep cervical glands, close to the lateral lobes of the thyroid body.

Development.—The larynx arises as a median grooved meso-branchial prominence between the ventral ends of the fourth and fifth visceral arches (p. 14), and behind the tuberculum impar (p. 593). The groove on its surface is the forward continuation of the pit which forms the pulmonary diverticulum, and which, deepening and branching, gives rise to the bronchial tube system. The anterior prominence, which bounds the groove in front, becomes sharply defined and rises, becoming the epiglottis medially, and the folds passing backwards from it become the aryteno-epiglottidean folds, on each side of which is the sulcus between the third and fourth arches, which becomes the pyriform sinus. The thyroid cartilage is derived from the expanded cartilage in the fourth arch, but the rest of the larynx is but a specialisation of the wall of the bronchial diverticulum. The cricoid cartilage is of the same nature as the rings of the trachea, and the arytenoids and the accessory cartilages are

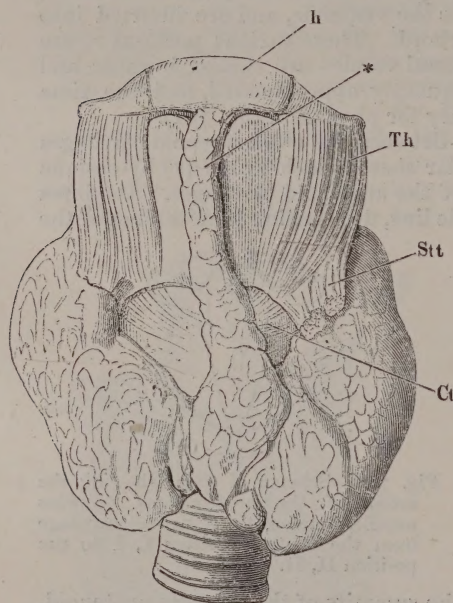


Fig. 703.—Thyroid body with an uncommonly large middle lobe, *; h, hyoid bone; Th, thyro-hyoid muscle.

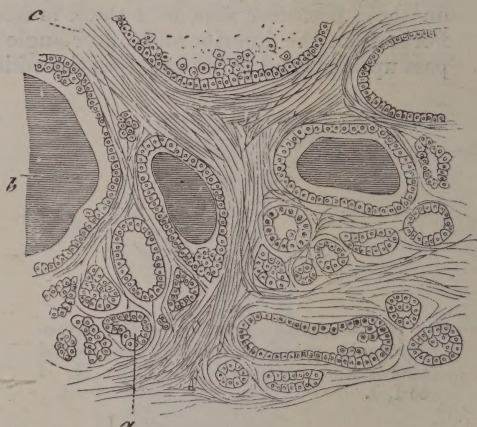


Fig. 704.—Minute structure of the thyroid body—*a*, closed vesicle; *b*, vesicles distended by colloid matter; *c*, interstitial areolar processes with vessels and fibres.

nodules of cartilage of a similar kind. These appear early, the hinder wall of the glottis in a seventh week fetus showing four small thickenings. Chondrification appears first in the thyroid cartilage in the sixth week, in the cricoid in the eighth. The vocal chords have begun to assume their typical form in the fourteenth week, and by the sixteenth the various parts are recognisable. The lumen of the suprarimal cavity is somewhat T-shaped at first, and that of the infrarimal is a sagittal slit, and this peculiarity in shape is retained until comparatively late in foetal life. The infantile larynx grows quickly until the seventh year, then enlarges slowly until puberty, when growth becomes rapid, and the adult size is reached about eighteen. The male larynx in the adult measures 6 cm. long, and the glottis averages 22 mm. in length, the true vocal chords being 15 mm. The female is only about 5 cm. long, and the glottis 16 mm. long, the true vocal chords being 10.5. The true vocal chords of the infant at birth measure 5 mm., of the child of seven, 8 mm. The pitch of the voice is consequently higher in the child, and diminishes with the lengthening of the chords, sinking usually an octave at puberty in the male.

507. THE THYROID BODY (fig. 703) consists of two pyriform lateral lobes, one on each side of the trachea, united by a median isthmus, which

crosses in front of the second, third, and sometimes the fourth tracheal rings. Each lateral lobe is about 6 cm. long, 3 broad, 15 mm. thick. Its narrow end rises as high as the thyroid cartilage, the broader end is below about the level of the sixth ring, and it lies under cover of the *sterno-thyroid*, *sterno-hyoid*, and *omo-hyoid* muscles and their fascial sheaths; its superficial aspect is rounded, its deeper is moulded on the trachea and oesophagus, and has the carotid artery and its sheath behind and to its outer side. The edge of the *sterno-mastoid* also overlaps it.

The body is larger in the female than in the male, has a volume of about 25 ccm., and weighs about 35 grammes. The right lobe is a little larger and broader than the left.

Above the attachment of the isthmus to the left lateral lobe is a pyramidal **middle lobe**, whose apex is connected by a tough areolar cord to the thyro-hyal membrane. Over this a slip of the *sterno-hyoid* is often segmented from the rest of the muscle to form a *levator corporis thyroidei*, which descends from the lower edge of the basihyal to the apex of the pyramidal lobe. This muscle is supplied by a separate branch of the descendens cervicis nerve.

The thyroid body has a large blood supply, the calibre of its arteries being at the rate of 0.7 sq. mm. of cross-section of lumen to each ccm. of body. The superior thyroids from the carotids descend and break up above at the apex of each lobe, and are distributed by terminal branches chiefly to the front and inner part (§ 438). The inferior thyroids (§ 423) from the subclavian arteries chiefly supply the lower, outer, and back parts, but these vessels anastomose freely with each other. The superior thyroid veins accompany the arteries as far as the internal jugular vein. The middle thyroids join the common jugular vein lower down, both these vessels crossing the carotid artery. The inferior thyroid veins descend as an irregular plexus on the trachea to join the innominate veins; occasionally, a middle thyroid artery arising from the innominate ascends on the trachea to supply the body. This vessel, like the inferior thyroid veins, is endangered in tracheotomy. There is usually 1.3 sq. mm. of venous lumen for each ccm. of a healthy gland.

Each lobe is reddish or purplish brown, and invested by an areolar capsule, which sends imperfect septa into the organ, in which the vessels travel and ramify. The lobe consists of many irregular lobules united by an interstitial areolar tissue rich in white blood corpuscles and connective cells, and containing the branchings of the vessels surrounded by meshes, not uncommonly filled with a colloid substance. Each lobule consists of many closed follicles about from .03 to .08 mm. in diameter (fig. 704). These cavities are rounded, lined in the infant by a cubical epithelium, upon a structureless membrana propria, filled by a clear, sticky serous fluid, and surrounded by a vascular submucous layer. In the adult, the epithelium becomes lost and the follicular wall degenerates, the interior becoming filled with colloid matter. The capillaries in the walls are very close meshed, large, and often varicose. The juice exuding from a cut thyroid body contains colloid matter, broken up epithelium, and blood corpuscles in different conditions of disintegration. Nerves are few, derived from the sympathetic, and they accompany the blood-vessels; lymphatics begin in lymph spaces between, but not in, the walls of the follicles, and form a close superficial plexus on the body, ending in the lymphatic ducts of each side.

The thyroid is probably in some sort a blood-forming body, and seems to regulate the production of mucin in the body; as when extirpated, a condition allied to myxœdema is

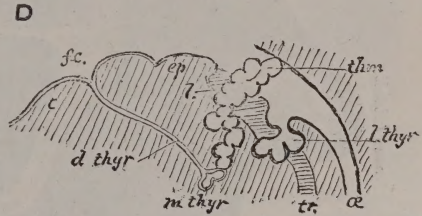


Fig. 705.—Diagram of the formation of the thyroid body—*t*, tongue; *ep*, epiglottis; *l*, larynx; *æ*, oesophagus; *tr*, trachea; *d. thy.*, thyroid or thyro-glossal duct descending from the spot afterwads marked by the foramen cæcum; *thm*, rudiment of thymus; *l. thy.*, lateral lobe of thyroid.

produced. It has also some obscure connection with the nutrition of the head, as when diseased or extirpated, a condition of idiocy, known as cretinism, is produced. In one curious form of disease, enlargement of this body is associated with exophthalmos and palpitation of the heart, probably due to paralytic conditions of the vasomotor nerves of the carotid system.

The thyroid body is a neoplasm arising on the rudimental **thyro-glossal duct** (§ 475), which represents the hypobranchial tube of proto-vertebrates, and arises in the fourth week of embryonic life as a diverticulum from the floor of the mouth, between the median and the two lateral parts of the tongue. It dips downwards to the level of the ventral surface of the fourth pair of branchial pouches, bifurcating at its fundus, and giving rise to the middle lobe and isthmus. Here it is supplemented by a pair of lateral outgrowths, derived from the epithelium of the fourth branchial pouch, which give origin to the lateral lobes. The upper part of the duct becomes reduced to the areolar cord, above described; but the terminal follicles become dilated as those of the organ. At birth, this organ is about $\frac{1}{300}$ th of the weight of the body; in three months it has diminished to become $\frac{1}{1200}$ th; at the end of one year, $\frac{1}{400}$ th; and in the adult it is usually less than $\frac{1}{2000}$ th.

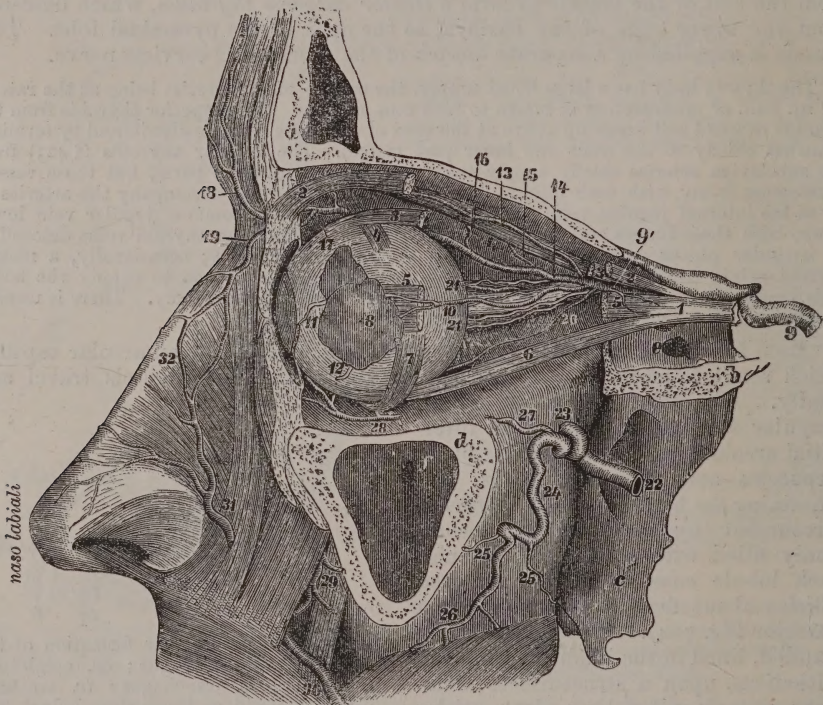


Fig. 706.—Superficial dissection of the nose—18, supratrochlear artery lying in the pyramidalis nasi; 32, insertion of compressor nasi; 31, levator labii superioris alae nasi, levator proprius alae nasi posterior crosses the ala of the nose towards the nostril to the left of 31.

The structure of the three bodies, which, arising as ventral diverticula from the pharynx, forms an interesting contrast. In the lungs (p. 14) the tubules persist and become air tubes, the epithelium thins, and the vascular element becomes the chief peculiarity of the lining of the outgrowth. In the thymus (p. 343), whose median part arises as a ventral pouch from the third visceral pouch, the terminal follicles atrophy, the tubules become obliterated, and the interstitial lymphoid tissue of the wall is that which becomes specially developed. In the thyroid the follicles themselves enlarge and become modified, and the tubules disappear. The specialisations of function which give rise to the modification of structure in the two last are not yet understood. Occasionally, the thyro-glossal duct remains pervious in part, and sometimes from the development of follicular tissue about it, accessory *suprathyroid*, *prethyroid*, or *suprathyroid* lobes of the thyroid are

developed. Sometimes closed follicles, like those of the thyroid body, exist at the bottom of the foramen cæcum, which is the lingual end of the duct. Cystic dilatations of these follicles are not uncommon. The dual arterial supply is correlated with its dual origin.

508. THE NASAL CAVITIES open posteriorly into the pharynx by the choanæ or posterior nares (fig. 685), and anteriorly on the face by the nostrils. The latter are narrow ovoid openings, bounded externally by the **nasal lobe** (*ala nasi*), internally by the **columna nasi**, and lined by skin continuous with that of the nose and lip.

These openings average 15 cm. long by 6 broad in the female; 18 by 7 in the male (European). They are usually wider and shorter in other races; and their long axes, which in the European diverge backwards at an angle of 25° , in negroes diverge at an angle of 90° or upwards.

The nasal skin is thin and loose over the bones, more firmly attached to the surfaces of the cartilages, most closely tied to the dense areolar and fatty tissue which makes the nasal lobe. Its vessels form a superficial network in the corium, liable to passive hyperæmia from many causes. The tough reticular deep layer of the cutis is a common site of lupus. Sweat glands and fine hairs sunk in small follicles, into which large sebaceous glands open, are scattered over the surface of the nasal tip; about 60 being found in a sq. cm. These open obliquely, and are liable to be blocked up, so giving rise to inflammatory spots.

Dissection.—Divide the skin along the middle of the nasal ridge and around the margin of the nostril, and reflect it outwards; a few weak subjacent muscles are exposed. The nasal insertion of the *frontalis* (*pyramidalis nasi*, p. 527) is seen descending from the forehead to be lost in the skin over the bones.

Compressor nasi (fig. 706), a thin, somewhat triangular, fasciculated muscle, with indefinite borders, arises from the front of the maxilla on each side of the opening of the *pyriform aperture* (p. 206), and expands thence upwards and inwards to be inserted into the subcutaneous tissue over the nasal ridge for nearly its whole length. At its origin, its separation from the *levator anguli oris* is artificial, and it underlies the *levator labii superioris*

and the nasal branches of the infraorbital vessels and nerves. The lowest fibres lie in the substance of the lip below the nostril, having no bony origin, and ascend to be inserted into the columna nasi (*naso-labialis*). The middle fibres have likewise no bony origin, but arise in the substance of the upper lip at its upper attachment and pass into the tissue of the ala of the nose (*depressor ala nasi*). Only the upper and outer fibres have normally a bony origin, but any division of these parts into separate muscles is artificial.

This muscle is a segmentation of the deeper or sphincter-colli stratum (§ 406), the superficial or platysmal layer of nasal fibres being represented by the nasal insertion of the *levator labii superioris*. The fibres occasionally figured as *levator proprius ala nasi anterior* and *posterior* are detached inner fibres, segmented from the *levator labii superioris*. Occasionally there are a few fibres which descend into the ala nasi from the alar cartilage. One such fascicle passes forwards to the tip of the nose (*compressor narium minor*), and another passes backwards to the skin of the margin of the nostril (*dilatator naris anterior*); but these muscles are rarely distinct.

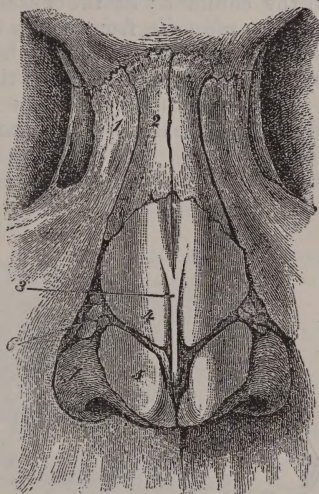


Fig. 707.—Front view of nasal cartilages—1, nasal process of maxilla; 2, nasal bones; 3, septal cartilage; 4, lateral cartilage; 5, alar cartilage; 6, sesamoid cartilages; 7, ala nasi.

These muscles are supplied by the superior bucco-labial branch of the facial nerve (§ 456). The skin overlying them is supplied by the infratrochlear branch of the nasal nerve (§ 524), the infraorbital branch of the superior maxillary (§ 533), and the terminal filaments of the nasal (fig. 614), all from the fifth pair.

In the tissues on the side of the nose the nasal branch of the facial artery (fig. 706) ramifies, anastomosing above with the angular branch of the transverse facial and the nasal branch of the ophthalmic artery (*ib.*, 19), and below with the superior labial.

The nasal cartilages seen by removing these muscles are six pairs and one single (fig. 707).

1. The **alar cartilages** bound the nostril laterally, in front, and internally, forming the tip of the nose and curving backwards above, not in, the true ala nasi. These are a pair of curved structures, whose *inner crura* lie side by side in the columna; at the nasal tip each cartilage bends outwards, forming the *angulus pinnalis*, from which the *outer crus* passes backwards as an ovoid plate which thins out towards the bony edge of the pyriform aperture, and is attached by fibrous membrane to the thin nasal edge of the maxilla.

2, 3. In this fibrous tissue on each side are two small **accessory quadrate cartilages**, each about 2 mm. in diameter (below the line from 3 in fig. 707).

The lower border of the alar cartilage is closely connected by its fibrous sheath to the skin of the *alar sulcus*, above the true nasal ala.

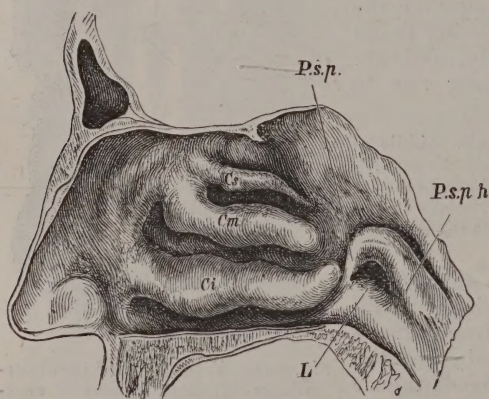


Fig. 708.

The tip of the nose consists of the anguli of the two alar cartilages here tied together by transverse fibres and an intervening elastic reticulum. Occasionally a separate cartilaginous strip overlies the outer crus of the alar cartilage.

4. Between the alar cartilages and the nasal bones are the **lateral expansions** of the septal cartilage, appearing as a pair of triangular plates, attached above and externally to the lower edges of the nasal bones by an

intervening fibrous tissue, continuous from the periosteum to the perichondrium. These are marked off from the median part of the septum by notches below and medially, but are otherwise inseparable from it (fig. 707, 4).

5. Two small **sesamoid cartilages**, about 5 mm. long by 3 broad, occupy, but do not fill, the triangular interspace between these, the septal and the alar cartilages (below 4 in fig. 707).

6. The **Jacobsonian cartilages** and the single or **septal cartilage** will be seen later.

Dissection.—Remove the portion of the lower jaw attached to the anterior fragment of the skull. Saw through the hard palate and alveolar arch sagittally to the left of the middle line. Divide also sagittally with the saw the roof of the nose on the left side of the crista galli, cutting through the frontal, the left side of the cribriform plate, the left nasal bone, and the body of the sphenoid. The cavity of the nose is thus opened on one side (fig. 708).

The **nasal fossæ** of the two sides are separated from each other medially by the thin flat **septum**, which is rarely symmetrical in the adult, as it has become displaced to one side or other, usually to the right, by the force of the

air and the unequal closure of the nostrils in blowing the nose. The outer side of the nasal fossa on each side is irregular, presenting three projections, the *spongy bones* and three intervening recesses, the *meatuses* (fig. 309).

The cavity of the nose is divisible into three regions :—

1. **The vestibule**, which extends inwards from the aperture of the nostril on the inner surface of the alar cartilage and a little above it. This space is lined by modified skin, bearing strong and projecting hairs (*vibrissæ*) which serve to prevent the entrance of the coarser particles of dust into the nose. These hairs are stronger in the male sex, and, in some races, notably in the celtic people of western Europe. The skin lining this cavity is covered by a stratified squamous epithelium, has a few sebaceous glands, and few papillæ, is tightly tied down to the underlying parts, and often presents a somewhat reticular appearance. In front, the cavity expands forwards into a pouch, the *apical recess*; behind and externally, it presents a sharp *marginal fold*.

2. Behind the vestibule the mucosa-clad *cavum nasi* is divided into two parts—the lower, wider region below the middle spongy bone is called the **respiratory tract**, and extends backwards to the posterior nares.

3. The uppermost part, the **olfactory tract**, is narrow, with a slit-like cavity extending upwards to the cribriform plate of the ethmoid bone.

The irregular outer wall of the respiratory tract in front of the spongy bones and above the vestibular area is called the **region of the atrium**. This space has a flattish outer surface, and lies behind and beneath the nasal bones, whose inner surface bounds a narrow *anterior nasal groove* anteriorly and above.

At the upper and back part of the atrium, as it ascends towards the frontal bone, this wall projects into a convex eminence, the **agger**, a rudiment of the anterior or naso-turbinal bone found in some mammals.

The **inferior meatus** is bounded below by the nasal floor, above by the **inferior turbinal bone**. The mucosa covering this bone is thick, and often projects as a soft pulpy swelling posteriorly, where it lies opposite the middle of the posterior nares. By cutting away with the scissors this inferior turbinal, the roof of the inferior meatus is seen to rise external to it at its anterior third, and the oblique opening of the nasal duct is here visible near its highest point (p. 646). Patches of vascular tissue simulating erectile tissue are found in the submucous layer, and are liable to engorgement in catarrh, and to chronic induration.

On the floor of the nose, below this meatus and close to the anterior end of the septum, there is a small conical pit which, after a short course, ends blindly. A pin forced into this pit can be made to traverse the bony anterior palatine canal (fig. 311) and to emerge on the incisive papilla in the mouth, its track representing the course of the **obliterated canal of Stenson** (p. 596). This canal is seldom pervious, even in the infant at birth, and usually becomes obscure with advancing years; a cord of soft connective tissue in which there is a central, very interrupted core of broken-down epithelium, is usually its only representative. On the wall of this cord the palatine branches of the naso-palatine arteries descend to the palate; and through two fine holes (**canals of Scarpa**), which traverse the bone in front and behind the Stensonian canals, the palatine branches of the naso-palatine nerves pass, the left nerve usually lying in the foremost canal. These fine tubules open below into the common central rudiment of the anterior palatine canal. The nerves here display a slight thickening, but no trace of a true ganglion (pseudo-ganglion of Cloquet).

Jacobsonian Organ.—Above the opening of Stenson's canal on each side there is a slight oblique thickening on the nasal septum, and, at its anterior and inferior part, a minute opening, about 0.3 mm. in diameter, leads into a blind pouch about 6 mm. long, whose fundus is directed upwards and backwards. This pouch is the rudiment of the **Jacob-**

sonian organ, and although its opening is not always apparent, yet when sought for by section it is always to be found.

The Jacobsonian Cartilage.—A minute strip of cartilage runs beneath this tube, but does not encapsulate it as in many mammals. This is attached by a rather firm areolar sheath to the septal cartilage, but is structurally quite distinct therefrom; it is usually about 1.5 mm. wide and 4 mm. long.

The rudimental Jacobsonian tube is lined by ciliated epithelium, and in the embryo a minute twig of the olfactory nerve appears to descend towards, if not to, it, but this has apparently atrophied in the adult.

The space above the inferior spongy bone is the **middle meatus**, which is overlapped above by the projection of the **middle turbinal bone**, a portion of the ethmoid. The lower border of this bone is prominent, and forms the boundary separating the respiratory from the olfactory tracts. The wideness of the former and the narrowness of the latter can be seen in vertical coronal sections, and should be remembered in surgery (fig. 709). The cavities are often unsymmetrical.

It is along the floor of the nose in the respiratory tract that instruments are passed to plug the posterior nares and to catheterise the Eustachian tube.

; The front border of the middle turbinal bone (fig. 309, 12) projects as a flap, the **operculum**, whose anterior and inferior margins meet nearly at a

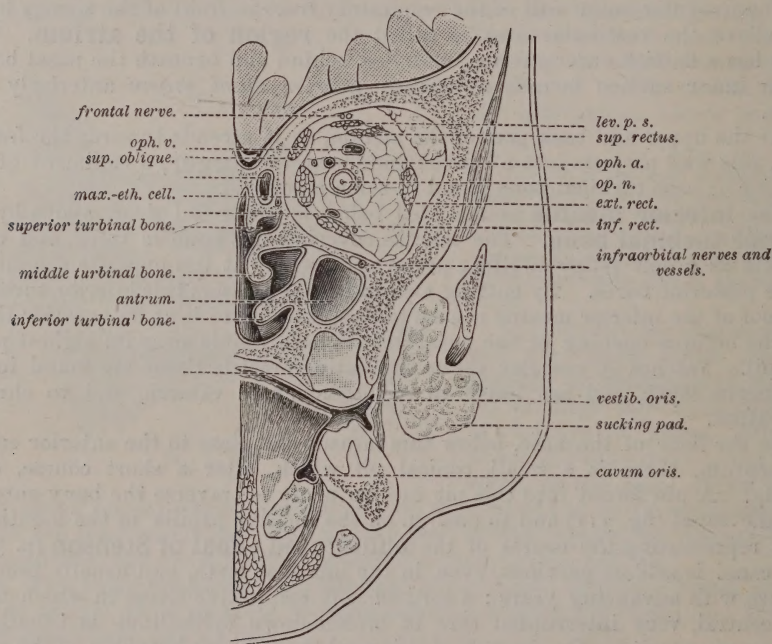


Fig. 709.—Coronal section through the nose.

right angle (*the opercular angle*), and this, when raised, shows beneath it a curved groove, the **infundibulum**, which ascends forwards, opening above by a short wide passage into the frontal sinus.

By cutting off this border with a pair of scissors, the infundibulum is fully exposed and its sharp-edged gutter-like anterior boundary, the **bulla ethmoidalis**, is fully shown; along the course of the infundibulum are the openings of the **fronto-ethmoidal** and **lacrymo-ethmoidal** cells.

Above and behind the middle turbinal bone is a short and anteriorly upturned **superior meatus**, into which the **posterior fronto-ethmoidal cells** and

the palato-ethmoidal cells open. Still higher, is the small **superior turbinal bone**, above which is a **fourth meatus** beneath the sphenoturbinal which here forms the nasal roof. Into this the sphenoidal sinus opens by a small, round, forward directed opening. Occasionally, a lobe of the superior turbinated bone appears as a fourth spongy bone, the **concha suprema**.

The mucous membrane lining the respiratory tract of the nose is lined by ciliated columnar epithelium, between the bases of whose cells are smaller intermediate cells. The corium beneath has no papillæ, but contains very many and very freely communicating blood-vessels, especially veins, which give to it a cavernous structure, especially in patches. Sunk in this tissue are many acinose glands, which are for the most part aquiparous, though some are mixed. The mucous secretion of the nose is chiefly derived from the muciparous cells scattered through the general epithelium, many of which usually exhibit the goblet condition. The space between the plane of the openings of the choanæ and the hinder ends of the turbinal bones has been named by Allen the **posterula**.

The glands are about 70 to the square centimetre on the septum, fewer and larger on the inferior turbinal. Arteries are numerous, though smaller than the veins, and lymphatics are abundant, the mucosa being studded with minute patches of lymphoid tissue, through which a constant wandering of white corpuscles takes place to the surface. The deep layer of the mucosa is continuous with the thin underlying periosteum. Irregularly scattered fibres of smooth muscle surround many of the larger mucous glands, and are mixed up with the venous plexuses. The epithelium seldom exceeds 60μ in thickness.

The mucous membrane of the olfactory tract of the nose is thick and soft, and its epithelium is ciliated only in patches, but these islands are included in a general area of non-ciliated epithelium where the mucosa is yellowish-brown. The non-ciliated region includes the superior spongy bone, the upper third of the septum, the roof of the nose and the upper half of the middle spongy bone; the epithelium is here thick, columnar (100μ) with cells of three kinds:—

1. Columnar cells, each within an oval nucleus near its surface (fig. 50, E). The free end of each cell is longitudinally striated, the attached end is irregular, narrower, and moulded to the neighbouring cells, expanding into a foot on the corium. The yellow pigment of this region is chiefly contained in these cells.

2. Rod cells or smelling cells (fig. 50, N). These have an oval nucleus beyond which the cell narrows into a cylindrical rod, whose free end is often divided into hair-like processes. The attached end narrows and becomes a moniliform fibre, probably nervous. These cells vary much in the relative length of their rod-like and their attached ends.

3. Basal cells, which are flat or branched, resting on the basement membrane and anastomosing by their processes. An exceedingly fine cuticle, the *membrana limitans olfactoria*, covers the surface of the membrane, but it is pierced by the protruding rod-like ends of the smelling cells.

Mixed with these various kinds of epithelium are the ducts of *Bowman's glands*, which are tubular glands with few alveoli, simpler than those in the respiratory tract, and opening by fine ducts; each tubule is lined by a polygonal granular epithelium. These glands co-exist with the non-ciliated epithelium, and the ordinary glands before described occur with the ciliated epithelium.

The olfactory region receives the distribution of the branches of the *olfactory nerves*. These commence as about twenty-five olfactory threads from the

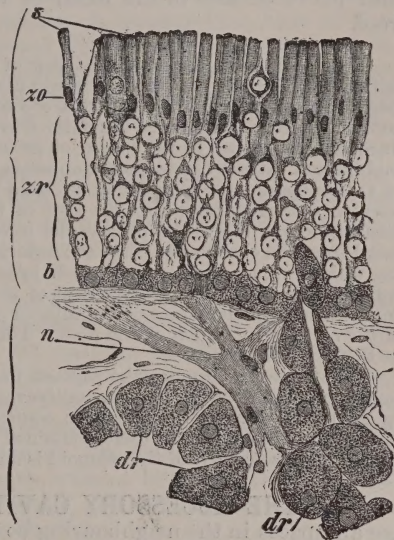


Fig. 710.—Section of olfactory mucous membrane of rabbit, $\times 560$ —s, disc; zo, zone of oval nuclei; zr, zone of spherical nuclei; b, basal cells; dr, Bowman's glands; n, olfactory nerve filaments.

ventral surfaces of the olfactory bulb and traverse the foramina in the cribriform plate, sheathed in processes of dura mater. The filaments which pierce through the outer row of holes are the most numerous. Those which pierce through the inner are the fewest but the largest. These nerve threads form close-meshed anastomoses, lying at first in grooves on the surfaces of the bones, then, as they branch, becoming more superficial, and finally ending in the olfactory epithelium. Each of the fibrils is non-medullated, consisting of an axis cylinder within a sheath of Schwann. Along with these nerves descend perineural lymph tracts, by which the lymphatic tissue of the olfactory region is directly continuous both with the subdural and the subarachnoid lymph spaces (p. 60).

Descending obliquely on the septum is the naso-palatine nerve, and on the hinder part of the outer wall the sphenopalatine nerve ramifies (§ 534). The nasal branch of the ophthalmic nerve (§ 524) passes along the anterior part of the sulcus olfactorius and on the inner surface of the anterior nasal groove. With the naso- and sphenopalatine nerves are their companion arteries, which are the terminal branches of the internal maxillary (p. 581), and, with the branches of the olfactory nerves, minute branches of the anterior and posterior ethmoidal arteries from the ophthalmic descend. The pterygo-pharyngeal artery and nerve lie also in the canal of that name at the hinder part of the nasal roof.

The nasal fossæ develop as a pair of anterior pits on the front of the embryonic head between the middle and lateral fronto-nasal processes (p. 16). These first appear at the beginning of the fourth week, and are continuous with the mouth. In the seventh week a secondary groove appears on the outer side of the middle nasal process, the rudiment of the Jacobsonian organ. In the course of growth the maxillary lobe joins the outer part of the middle and lateral fronto-nasal processes, closing the groove along which the nasal duct (§ 513) becomes later secondarily developed. The nasal fossæ at first appear as two deep narrow pits which open into the roof of the mouth and pharynx from the nostril to the basisphenoid. When the premaxillæ have, by their development in front, separated the nasal from the oral border, then the anterior nostril is shut off from the naso-palatine opening which extends along a line which joins the anterior palatine foramen to the body of the sphenoid (fig. 33). The development of the secondary palate (fig. 35) afterwards shuts off from the mouth the region of the inferior meatus (*ductus naso-pharyngeus*), or the main part of the respiratory region of the nose. The projection of the outer nose begins to be visible at the second month.

The structures forming the septum form an interesting morphological study, the septal cartilage is the survival of the primitive mesethmoid cartilage formed by the fused trabeculae (p. 245); the vomer is a parastotic ossification of two lamellæ which have embraced, and caused the absorption of, their contained lamella of cartilage and then have fused. The *lamina perpendicularis* of the ethmoid is an ectosteal ossification in the mesethmoid.

509. THE ACCESSORY CAVITIES communicating with the nasal fossæ are air spaces in the neighbouring bones, primarily developed in order to lighten the bones, which, from their physical conditions as support bones for the brain, require to have a certain amount of extension. Secondarily, they act as resonating cavities. They are—

I. The ethmoidal cells.—These spaces, as seen in the description of the bone (p. 230), are disposed in all directions around the lateral circumference of the ethmoid. They arise as peripheral pouchings of the mucosa, expanding the wall of the primitive cartilaginous nasal capsule, and they become secondarily related to the other surrounding bones when the lamellæ of the ethmoid, which at first enclose them, undergo absorption. The fronto-ethmoidal cells are two, and open into the infundibulum; so do the two lacrymo-ethmoidal and the anterior maxillo-ethmoidal. Each of these has a separate opening. The mucosa lining these cells is thin, with a ciliated epithelial surface, a thin basement, and a submucous tissue, inseparable from the periosteum. There are no mucous glands in the lacrymo-ethmoidal or maxillo-ethmoidal cells, but there are a few in the fronto-ethmoidals. There are two posterior maxillo-

ethmoidal, one palato-ethmoidal, and one sphenothmoidal, cells. The membranous linings of the lacrymo- and anterior maxillo-ethmoidal cells are innervated by the nasal nerve, the sphenoth and palato-ethmoidal cells by branches from the sphenopalatine.

2. **The frontal sinus** is usually unsymmetrical, larger on the side from which the nasal septum is bent, and for the same reason; its lining membrane is thicker, and receives filaments of the supraorbital nerve, and contains a few aquiparous glands. The bulge of the glabellar area of the forehead depends on its size.

The cavity begins to develop at seven years of age, and is at first a pouch of mucosa uncovered by cartilage, in which respect it differs from all the other outgrowths. It is usually larger in males, but in females it may also be capacious, in which case it very often rather bulges the internal table of the skull inwards than the forehead outwards. The interfrontal septum is occasionally thick, and is especially so in metopic skulls, but small sinuses usually co-exist with metopism. Sometimes the sinus encroaches considerably on the orbital roof. The sinus is very large in Australian skulls.

3. **Antrum maxillare** (fig. 707).—The mode of development of this cavity has been noted already (p. 237); its extent is variable, and it may even extend into the anterior part of the zygoma. Its mucosa is thicker than that of the other cavities, and contains a number of mixed gland-acini. In shape it is a three-sided pyramid, and its opening is a small oblique slit or oval opening about 8 mm. long. The borders of the opening are membranous, but if this be torn away, the mouth appears to be bounded by the inferior turbinal below, the uncinate process of the ethmoid above, the palate bone behind, and the lacrymal or ethmoidal in front. In its roof are branches of the superior maxillary nerve, which supply its mucosa, and of the infraorbital artery; in its front wall the anterior dental nerves and arteries descend; in its hinder and outer wall the posterior superior dental nerves and vessels are enclosed, and below lies the alveolar arch, containing the molar teeth.

4. **The sphenoidal sinus** is also of variable extent, not uncommonly stretching into the roots of the pterygoid processes. Its mucosa is thin, with about 20 glands, mostly muciparous, and its opening is particularly small. Prominent ridges of bone usually project into its cavity, often subdividing it into upper and lower compartments. This cavity appears first in the beginning of the third year as pouches of the mucosa, projecting into the spaces between the cornua Bertini and the basisphenoid. The former become flattened and hollowed about the seventh year. It may extend into the pre- as well as the basisphenoid; so may the sphenothmoidal cell, giving in section the appearance of four cavities within the sphenoid.

The average area of these accessory cavities in proportion to the nasal fossæ is in the adult male 135 : 100; in the average female 126 : 100; but they enlarge rapidly with advancing age, and they may even be in the proportion of 175 : 100. The antrum is usually the largest, not uncommonly larger than all the others taken together. These cavities have a considerable influence in modifying the timbre of nasal sounds. These cavities, as well as the nasal fossæ, are seldom perfectly symmetrical.

THE EYE AND ITS APPENDAGES.

510. Before removing the skin covering the eyelids, the eyebrow, lids, and the front of the eye should again be examined (§ 396).

The **caruncula lacrymalis**, which should now be dissected, consists of a small mass of areolar tissue, covered by mucous membrane, and containing a group of aborted hair bulbs and glands.

The skin covering the free border of the lids, where they are opposed to each other in closure of the eye, becomes modified, and is closely tied to the subjacent tarsal body. It is garnished with large papillæ, which, however, are quite bedded in the stratified epidermis; and it presents, close to the ocular margin, a row of fine holes, the mouths of the *Meibomian glands*. The lower surface of the upper lid in closure is oblique, its anterior limbus descending lower than its posterior, while in the lower lid the posterior limbus is the higher. At the posterior limbus the skin becomes continuous with the *conjunctiva*; and as this ascends beneath the upper lid to the fornix *conjunctivæ superior*, it is at first tightly bound to the fibrous tissue beneath, but above is more loosely connected as far as the fornix, where it turns acutely, and is reflected over the front of the eyeball. It is similarly attached on the lower lid. The *ocular conjunctiva* which covers the white of the eye (*sclerotic*) is loosely attached, and can be easily lifted off by dissection; the continuation of the membrane over the transparent window of the eye or *cornea* is firmly tied down.

The surface of the conjunctiva under the upper lid shows a faintly swollen or ridged area externally, beginning from the external canthus and extending for 1 cm. upwards and inwards towards the superior fornix. On this **area lacrymalis** the ducts of the tear-gland open.

Of the two lids, the upper presents much the larger *ocular area*, and is the more extensile. When the lids are closed, the conjunctiva becomes a closed cavity, receiving the tears externally, and discharging them through the puncta internally. The substance of the lid feels soft and pliant, except along its margins where the tissues are condensed. This firm part is the **pars tarsalis**, the softer circumference is the **pars orbitalis**.

The skin of the lids is sparingly beset with small papillæ, except close to the outer limbus where these are larger; it is sensitive to titillation, but not very acutely sensitive to pain. The subcutaneous tissue is loose and areolar, without fat.

The size of the rictus varies with the condition of the lids and the position of the eyeball. With eyes looking straight forwards the lower edge of the upper lid is a little below the level of the top of the cornea, and the lower lid is on the level of the lower border of the cornea. With eyes raised to their maximum the rictus dilates, the upper lid is raised to the upper edge of the cornea, while a strip of white sclerotic is visible between the lower corneal margin and the lower lid. With downcast eyes the lower lid is conterminous with the lower corneal edge, but the upper sinks to the level of the top of the pupil. In ordinary closure the lower edge of the upper lid descends to the lower corneal edge.

Development of the lids.—At the second month of foetal life marginal folds appear above and below the eyeball. These rapidly extend, and their edges unite about the third month by a fusion of their epithelium when they come into contact, closing in the con-

junctional space. This remains as a shut sac until the beginning of the sixth month, when the edges again become separated. During this stage of union the Meibomian glands and hair sacs develop. These and the lacrymal glands at first are solid columns of epithelial cells. The average length of the adult *riectus oculi* is 29.5 mm.; often a little larger in females. The average width from inner canthus to inner canthus of the interocular space is 32 mm. in the Western European male, 30 in the female. The interval is greater in the Turanian races, averaging 36 mm. in the male, 34 in the female.

Only the anterior third of the surface of the eyeball is freely exposed in front between the fornices, and this consists of the cornea and a zone of the sclerotic, about 8 mm. in vertical and 10 in lateral breadth. At the middle

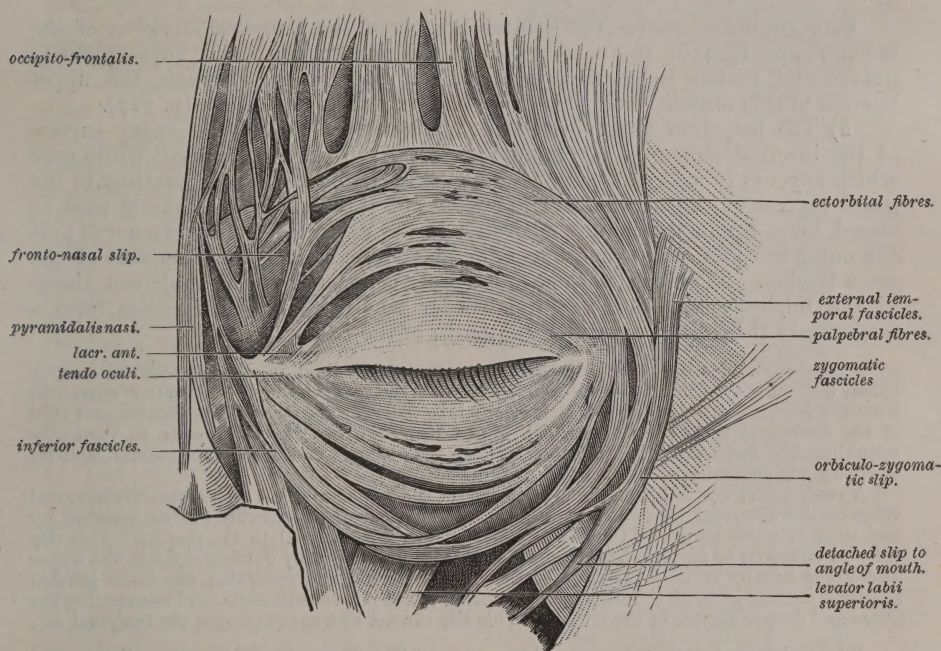


Fig. 711.—Dissection of the orbicularis palpebrarum.

of the front of the eye the dome of the cornea usually lies in the plane of the upper and lower orbital margins, which, therefore, protect the eye; but external to its middle line the eyeball usually projects beyond the sheltering bony ridges.

The eyeball occupies a portion of the anterior half of the orbit, but its axis is not coincident with that of the cavity, as it lies about 1.5 mm. nearer the outer and upper walls at the anterior opening of the cavity.

Dissection.—Divide the skin close to the palpebral margin of both lids, and from the internal canthus to the median line; divide it also vertically in the median line. Above and below it has already been divided. Reflect the flaps of skin from the two lids outwards. It is a matter of some difficulty to separate the skin from the subjacent muscle, and it cannot be done satisfactorily unless the dissection be carried from within outwards.

511. ORBICULARIS PALPEBRARUM (fig. 711).—The sphincter muscle of the eyelids is a thin flat layer of engirdling fibres, which may be artificially divided into two series:—(1) The outer, stronger, ectorbital fibres arise from the internal angular process of the frontal bone and from the subcutaneous tissue on the side of the root of the nose; these fibres pass upwards into the upper part of the brow, and then outwards over the external angular process

and front part of the temporal crest; there turning downwards, and finally inwards below over the orbital edge of the malar bone. They end by being inserted into the nasal process of the maxilla.

Only a certain proportion of the fascicles can be traced all round the eyelids, and hence the periphery of the muscle is hard to define. Many of the upper and outer fibres are lost in the fascia over the temporal ridge. Others beginning in the soft part of the brow-ridge are lost at the edge of the zygomatic arch, and others are there continuous into the *zygomatic* and sometimes the *levator labii superioris* muscles. The widest part of the muscle is at its outer part over the malar bone and front of the temporal fossa, and here its fibres are attached so closely to deep areolar processes of the dermis as to be with difficulty separable.

Into its outer border the orbital branch of the temporal division of the facial nerve (§ 456) is traceable, and the supraorbital and supratrochlear nerves and vessels lie at first beneath, and then pierce through, the upper portion of this muscle, into which the *frontalis* is inserted above (p. 527).

(2) The palpebral part of the muscle arises chiefly from the upper surface of the internal palpebral ligament (**tendo palpebrarum**), a small white cord which appears to pass downwards and inwards from the inner canthus to the nasal process of the maxilla. The fascicles of this part of the muscle pass in closed loops round the *rectus oculi*—first in the upper lid, then downwards past the outer canthus into the lower lid, and thence to the lower surface of the same tendon. This part is paler and closely connected to the subjacent tissue in the lid, especially near the free border where its lowest fascicles form a moderately thick band overlying the bulbs of the cilia.

Separate portions derived from this muscle are specialised in different directions. A thick, but only artificially separable deep part of the orbital fibres (*corrugator supercilii*) from the internal angular process is inserted into the deep surface of the muscles and skin of the middle of the brow-ridge, which it can draw downwards and inwards, so vertically wrinkling the forehead and producing a frown. This part can act independently, and its nerve-twig is generally specialised (fig. 657, 9).

A second part derived from the deep surface of the palpebral fibres arises from the lacrymal ridge on the lacrymal bone, and passes beneath the tear ducts outwards to be inserted by two slips into the border of the tarsal edges of the lids internal to the puncta. This slip (*Horner's muscle*) or **tensor tarsi** is best exposed a little later by cutting through the upper and lower lids by vertical incisions at their inner fourth, and reflecting the inner portion inwards, cutting through the conjunctiva external to the plica semilunaris, and so exposing the outer and deeper surface of the muscle. This slip can act as a compressor of the lacrymal sac.

The palpebral fibres close the lids; the orbital fibres draw the brow down, and the lower lid up, thus forcibly closing and wrinkling the edges of the aperture, producing radial wrinkles externally, which, when permanent, as in old age, where the skin has lost its elasticity and fulness, constitute "crow's feet."

In dissecting this muscle, not only its own nerve and the two before described nerves of the brow are to be seen, but the temporal branch of the temporo-malar (§ 532) and the infraorbital externally. Branches of the palpebral, lacrymal, and angular arteries also ramify among the fibres of this muscle.

Raising the muscle from without inwards, and throwing it inwards, a fine fibrous layer is shown beneath it in each lid, the **tarsal membrane**, attached marginally to the edge of the orbit, where it becomes continuous with the periosteum; as it passes towards the free edge of the lid this lamella thickens suddenly, and forms in the tarsal part of the lid a firm band, the **tarsal body**. The structure is of the same kind in the lower as in the upper lid, but weaker. These tarsal bodies consist of condensed fibrous tissue, and can be made by artificial separation from the tarsal membrane to appear as two stiff, arched plates—one above, larger; one below, narrower—extending along the edges of the lids. Internally, these are continuous into the inner strengthened band of the tarsal membrane, the **internal palpebral ligament**; externally, they are attached to a much thicker and stronger outer band of

similar nature, the **external palpebral ligament**. The free borders of the tarsal bodies are inseparable from the corium of the lid-margin; the attached borders when cut from the tarsal membrane are convex.

Along the free border of the lid a deep fascicle of the orbicular muscle has become displaced beneath the tarsal body, and forms the **subtarsal muscle**.

Upon the deep surface of the tarsal membrane is a stratum of unstriped muscle, the **superior palpebral muscle**, whose fibres stretch sagittally from the surface of the tendon of the *levator palpebrae* (§ 519) to the tarsal body.

By dividing the tarsal membrane along the supraorbital margin, a loose areolar and fatty layer is exposed, which easily breaks down, leaving an apparent space. In this dissection the strong ligament underlying the supraorbital nerve and bridging the notch, which is a specialised band of the tarsal membrane, is exposed. This band is occasionally ossified, converting the bony notch into a hole.

The tendon of insertion of the *levator palpebrae superioris* is here exposed as it passes forwards into the lid by removing the overlying fat; and by making a sagittal vertical section of the lid, its superficial tendinous fibres can be traced traversing the bundles of the palpebral muscle to be inserted into the skin of the lid below the orbito-palpebral fold.

This insertion and the deeper one into the conjunctiva will be better seen at a later stage.

In the lower lid the layers are comparable with those of the upper, but in place of the expansion of the tendon of the *levator* there is a much weaker and more limited expansion from the sheath of the *inferior rectus* (§ 530).

512. GLANDS OF EYELID.

—Two kinds of glands are embedded in the free margin of the lid:—

1. **Meibomian glands**, about 35 in the upper lid, and 24 of smaller size in the lower. These are long acinose glands arranged nearly parallel to each

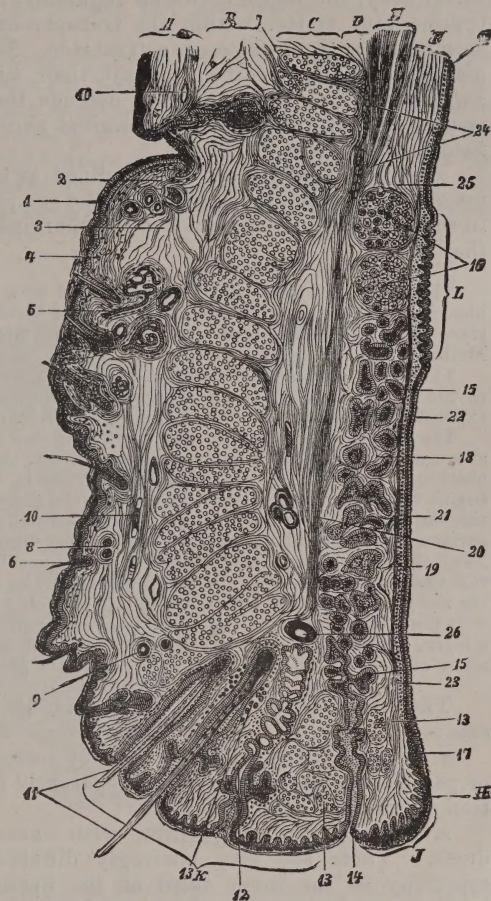


Fig. 712.—Section of the upper lid, $\times 10$ —A, skin; 1, epidermis; 2, corium; 3 and B, subcutaneous areolar tissue; C, orbicularis; 7, its upper fibres; D, broad ligament of the tarsus; E, musculus palpebralis; F, insertion of levator palpebrae superioris; G, conjunctiva; J, inner limbus of lid; K, outer limbus of lid; 4, pigment cells in corium; 5, sweat glands; 6, hair follicles; 8, palpebral nerves from supraorbital; 23, ditto from lacrymal; 9, 10, arteries and nerves; 11, cilia; 12, Möll's glands; 13, circular subtarsal muscle (Riolan's muscle); 14, Meibomian gland; 15, acini; 16, post tarsal lymphoid tissue; 17, transitional area of conjunctiva; 18, 19, tarsal tissue; 20, lower portion of tarsal body; 21, conjunctival epithelium; 22, papillary layer of conjunctiva; 23, ending of a nerve; 24, fat; 25, attachment of levator palpebra.

other. Each consists of a vertical duct, around which are disposed many rounded alveoli in single rows. They are sunk in the deep surface of the tarsal body, the depth of which regulates their extent, and, on account of the opaque fatty matter within the transparent-walled follicles, they can be seen shining through on the conjunctival side. These are united groups of sebaceous glands, specially modified to suit their situation and secreting the *smegma palpebrale*, which lubricates and defends the edge of the lid. The ducts are specialised involutions of the marginal skin (comparable with the mamillary field in the mammary gland).

2. **Möll's glands** are the modified sweat glands of the ciliary edge, and resemble the ceruminous glands of the ear passage (§ 537). They are arranged in several rows opening close to the marginal set of hair follicles behind which they lie.

The convoluted gland-pouch is surrounded by a spot of lax tissue, and when irritated by blocking up of the duct, inflammation of one of these follicles and the spot about it constitutes sty. Grandines and other encysted tumours more frequently arise in these than in the Meibomian glands.

The fornix conjunctivæ superior owes its existence to the attachment to the deep layer of the membrane—(1) of an expansion of the *levator palpebræ superioris*; (2) a similar expansion of the *superior rectus*; and (3) the attachment of the fibrous post-ocular capsule.

The palpebral conjunctiva, where it is attached to the tarsal body, has a smooth limbus; above which it exhibits a finely reticular surface, the netted ridges becoming gradually more obscure towards the fornix. This appearance is absent in the eyelids of the infant, but begins to appear within the first year. In the deeper layers of the region there is a discontinuous stratum of lymphoid tissue which contributes somewhat to the irregularity of the surface. It is the enlargement of these ridges which produces the roughness of "granular lids," the granulations being in some measure due to the pathological definition of areas of this tissue as adventitious lymphoid follicles. The epithelium for 1 mm. of the surface from the margin is stratified squamous, but it suddenly begins to thin, becoming only bilaminar over the attached part of the tarsal body, the surface layer being one of cylinder cells upon a layer, sometimes double or triple, of deeper, flatter cells. In old people with blear eyes, many of these cylinder cells have undergone the goblet transformation.

The conjunctival glands, other than those along the margin, are of three sets:—

1. **Simple tubular**, very sparsely scattered in healthy lids in the reticular or papillary area, but becoming apparently much more numerous in the condition of granular lids.

2. **Acino-tubular glands**, with one or two alveoli, opening into fine ducts. These are very sparingly diffused in the palpebral conjunctiva, especially at the inner third of the upper lid. They are most numerous in the superior fornix, where over fifty may be counted, but sparse in the lower lid, and rarely more than five open into the inferior fornix.

3. **Acinose Glands (lacrymal)**.—These, which are specialised and enlarged groups of gland follicles of the last form, have condensed into an elongated mass, occupying the lacrymal fossa in the frontal bone at the upper and outer part of the orbit, and may be exposed by dividing the tarsal membrane at the outer half of the supraorbital edge and cutting away a small portion of the overhanging bone with the chisel and bone forceps. It consists of a cluster of aquiparous glands, some of which overlies the expansion of the *levator palpebræ* tendon, and have become condensed into a bean-like solid mass, **glandula lacrymalis superior** (fig. 713, K), while others are loosely aggregated below this expansion, forming the **glandula lacrymalis inferior**. The superior gland extends outwards as far as the orbital margin and is obliquely placed, is about 14 mm. long, 20 broad, 3 thick, weighs .8 of a gramme, and has a volume of about 0.66 cm. It extends backwards for about $\frac{1}{5}$ the depth of the orbit, and is limited in its outward extent by the external palpebral ligament, internally by the edge of the *superior rectus*. It is encapsulated only by the surrounding

connective tissue, a process of which (the *ligamentum suspensorium*) ties it to the outer and anterior margin of the orbital edge. It receives at its hinder border the lacrymal nerve (§ 518) and the lacrymal arteries from the middle meningeal and ophthalmic.

The inferior gland lobules are loosely aggregated over the outer third of the fornix superior, extending to the external canthus.

Two or (usually) three ducts drain the tears from the superior gland, opening between the lobes of the lower gland, two passing into the fornix superior 5 mm. from the tarsal edge. One duct larger than the others passes outwards to open close to the edge of the external canthus. The smaller ducts of the inferior gland lobules are more numerous, generally seven or eight, and open on the irregular lacrymal area externally.

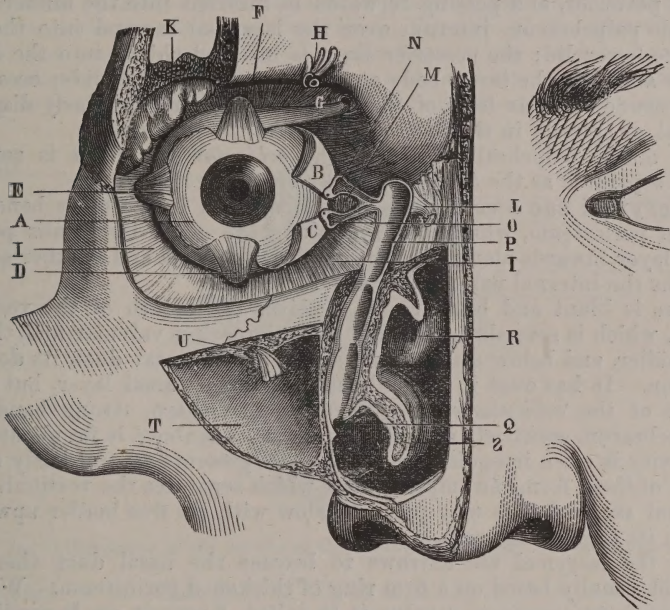


Fig. 713.—The lacrymal apparatus—A, eyeball; B, inner sixth of upper lid, the rest having been removed; C, inner sixth of lower lid; D, inferior rectus; E, external rectus; F, superior rectus; G, tendon of superior oblique; H, supraorbital nerve; I, orbital surface; K, lacrymal gland; L, tendo oculi; M, caruncula lacrymalis; N, ampulla of canaliculus superior; O, punctum inferior; P, lacrymal sac; Q, opening into inferior meatus; R, middle turbinal bone; S, inferior turbinal.

The lacrymal gland in structure closely resembles a salivary gland, especially the parotid, but the duct epithelium is not rod-like that of a salivary gland, and the basement layer is thinner, not basket-like.

Degenerated acinose gland follicles exist in the lacrymal caruncle, representing the gland of Harder, which usually co-exists with a third eyelid.

The vessels and nerves of the lid will be better seen at a later stage.

513. THE PUNCTA LACRYMALIA (fig. 713) are minute, transversely oval apertures placed on the hinder surfaces of the summits of the two papillae lacrymales on the lids, about 0.5 mm. from the innermost Meibomian gland; each punctum opens into a **canaliculus** which passes first vertically, then suddenly turns inwards, and the two unite internal to the caruncula to form usually a very short tube or small sac, the **vestibulum**, which opens internally into the lacrymal sac, of which, indeed, it is only a lateral pouch.

The superior punctum is 0.22 mm., the inferior 0.25 in diameter; the lower papilla is shorter, thicker, and farther out than the upper. The mouth of each canaliculus narrows into a very constricted area, the **angustia**, of 0.08 mm. lumen, beyond which it dilates into an **ampulla** which continues to the sharp angle at which the canaliculus bends inwards.

The **canaliculi** separately pierce the internal part of the tarsal membrane where this is attached to the periosteum, above and below that strengthened band of the membrane which forms the *tendo oculi*. Each canaliculus is lined by a stratified squamous epithelium on a basement layer, and has on its wall a layer of striped muscle derived from the *tensor tarsi*, whose fibres are somewhat spirally wound around the wall of the tube.

This muscle is bilaminar, its anterior lamella arising from the crista lacrymalis posterior, and passing forwards is inserted into the hinder lamella of the *tendo palpebrarum internus* over the lacrymal sac and into the canaliculus of the lower lid; the posterior layer is inserted chiefly into the superior canaliculus and into the tarsal body at its inner end in both lids; occasionally there are pseudo-valvular folds of the mucous membrane annularly disposed in the vertical, or spirally in the horizontal limb of the canaliculus.

A slip of the palpebral portion of the *orbicularis* in front is sometimes artificially separated as the *lacrymalis anterior* (fig. 711).

The **lacrymal sac** occupies the fossa lacrymalis in the orbit beneath the splitting of periosteum, which, dividing along the crista lacrymalis posterior, sends one layer inwards along the bone to floor the fossa and another outwards which forms the internal palpebral ligament.

This sac is blunt and blind above, receives the mouth of the vestibulum externally, which is sometimes guarded by an imperfect valvular fold, the valve of Rosenmüller, and below discharges itself into the nasal duct, its downward continuation. It has over it not only the periosteal tarsal layer, but also the inner part of the *orbicularis palpebrarum*. The sharp, strong band of the *tendo palpebrarum* constricts it, and the fundus rises above it for about 2 mm.

The cavity is often irregular, and its mucosa presents several fairly constant folds; one of these forms an imperfect lip, which separates the vestibulum from the lacrymal sac, and this may project below with its free border upwards, or above with its edge downwards.

Where the lacrymal sac narrows to become the nasal duct there is an annular fold usually based on a firm ring of thickened periosteum. When this is large enough to appear as a valve it is called Krause's or Beraud's valve. The sac is lined with ciliated columnar epithelium which begins in the vestibule. The submucosa is loosely tied to the periosteum by lax and vascular connective tissue, wherein there is often a cavernous arrangement of blood-vessels, especially of veins, continuous with the vessels of the superior nasal meatus.

Nasal duct.—From the lower end of the lacrymal sac the nasal duct descends, grooving the maxilla to open into the highest point of the inferior meatus beneath and external to the inferior turbinated bone; it is generally 16 mm. long and 4 in diameter, and passes downwards and backwards, its axis forming an angle of 70° with the horizon; its lower opening is usually prolonged into a gutter-shaped groove, with a crescentic mucous fold (the valve of Hasner) external to it, but may be round or oval.

The nasal duct system arises by the secondary canalising of a solid epithelial cord which persists in the interval between the maxillary lobe and the lateral nasal process.

Several anatomical arrangements produce the flow of the tears into the nasal duct. Capillarity, aided by the inward motion of the lids when closed, forcibly causes the tears to pass to the *lacus lacrymalis*. Horner's muscle, when the lids are closed, draws the puncta inwards and backwards, and may retract the hinder wall of the sac, expanding it. The *orbicularis* presses the tears downwards, and their return is prevented (1) by a feebly developed circular or spiral musculature, better developed on the lower than on the upper canaliculus, (2) by

the imperfect valvular apparatus, (3) by the pressure of a minute venous plexus in the deep layer of the wall of the duct.

514. DISSECTION OF ORBITAL NERVES IN THE CAVERNOUS SINUS.—Before proceeding to the dissection of the orbit, it is desirable to re-examine the dura mater which bounds the cavernous sinus, so as to trace the orbital nerves through it into the orbital cavity.

The apertures of four canals appear on the surface of the dura mater around the site of this sinus. The third nerve enters a canal in the dura mater above the fascicle of the convex border of the tentorium which is attached to the posterior clinoid process. The fourth pierces below the concave edge of the tentorium a little external to this process, and the fifth enters into the *cavum Meckelii* (§ 401) below the attached edge of the tentorium and above the angle of the petrous bone. By carefully cutting through and removing the surface of the dura mater, the courses of these nerves can be traced from this point until they enter the orbit through the sphenoidal fissure.

The **THIRD NERVE** enters the canal in the outer wall of the cavernous sinus close to the posterior clinoid process, above the slip of the tentorium which passes to that process, and internal to the band of the concave border which seeks the anterior clinoid process. It lies above and internal to the fourth, but as it rises to the sphenoidal fissure, that nerve ascends above it, as also does the

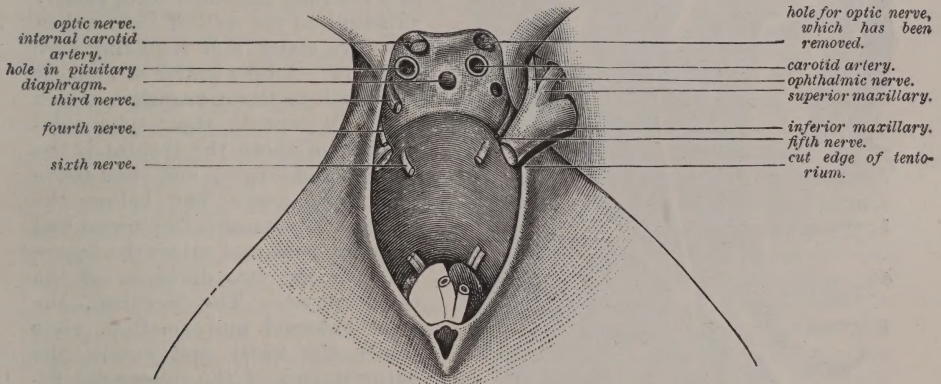


Fig. 714.—Dissection of the nerves of the orbit as they enter the cavernous sinus.

frontal branch of the fifth, both of which cross above it as it is in the act of entering the orbit. In this part of its course it receives (1) fine filaments of the sympathetic from the carotid plexus, and (2) a branch from the ophthalmic of the fifth. The third divides into an upper and a lower branch as it enters the orbit, the upper entering between the frontal and nasal nerves, the lower between the latter and the sixth.

515. THE FOURTH NERVE pierces the dura mater immediately below the free edge of the inner border of the tentorium, separated from the third by the tentorial attachment to the posterior clinoid process; it ascends in its canal outside the third nerve, above which it rises as it enters the orbit close to, and ultimately above, the frontal nerve. It receives in this course one fine sympathetic filament from the carotid plexus, and a fine branch from the ophthalmic nerve.

516. THE FIFTH NERVE passes beneath the fibrous archway formed by the attached convex edge of the tentorium as it passes over the angle of the petrous bone. Within this arch is the cavity of Meckel into which the nerve enters, and enlarges into a *triangular plexus* in whose meshes are many nerve cells. This ends anteriorly in a curved lamina of ganglionic matter, the Gasserian ganglion, which in outline appears crescentic with its concavity

backwards (fig. 715, 1), into which, however, only the sensory filaments of the nerve enter, the motor part lying below it unmodified. The triangular plexus is, for the most part, covered with an endothelial layer, and is, therefore, easily isolated; the ganglion is connected by areolar tissue to the surrounding membranes, especially above, and requires more care to isolate.

Three nerves start from the anterior or convex side of the ganglion, the ophthalmic branch above and internally, the maxillary (superior maxillary) in the middle, and the inferior maxillary below. The first and third diverge from each other at a right angle, the second and third at an angle of 60° . The motor part of the nerve adheres to the lower surface of the third branch and passes out with it.

The ophthalmic division is the smallest and is sensory; it appears as a laterally flattened cord, closely adherent to the wall of its canal in the dura mater, and requiring care to follow. After a course of 1 cm., it divides into three branches, which severally enter the sphenoidal fissure; of these the frontal is the highest and largest, and rises above the third nerve but below the fourth. The nasal is the lowest and most internal, and enters the fissure between the two divisions of the third nerve. The lacrymal, the most external and smallest, rises above the nasal and enters the outmost part of the sphenoidal fissure, piercing the firm fibrous tissue, which blocks up this part of the space.

Before its division, the ophthalmic receives some branches from the carotid plexus. It gives off (1) a communicating branch to the third; (2) occasionally one to the sixth; and (3) a fine thread to the fourth. It gives off also a fine pair of recurrent branches to the edge of tentorium. These cross and lie in the sheath with the fourth nerve, and have been mistaken for branches of it. The knob of the Gasserian

ganglion, from which the ophthalmic nerve arises, is possibly the remains of a separately arising ganglion, the ganglion meso-cephalicum of Beard.

517. DISSECTION OF THE ORBIT.—Divide the frontal bone by two sections with the saw; one vertical from above the inner angular process to the border of the orbit and carried back to the optic foramen; a second oblique dividing the bone from without inwards from the external angular process to the optic foramen. Remove with the bone forceps the thin orbital roof; strike forward the front portion of the frontal bone, but do not remove it.

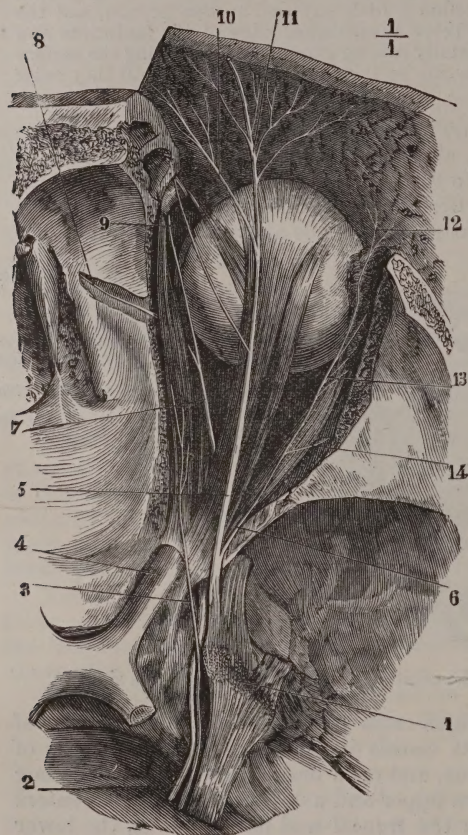


Fig. 715.—Nerves of the orbit, seen from above—1, Gasserian ganglion; 2, third nerve; 3, fourth nerve; 4, optic nerve; 5, frontal branch of fifth; 6, lacrymal; 7, nasal; 8, proper nasal; 9, infratrochlear; 10, supratrochlear; 11, supraorbital; 12, palpebral branches of lacrymal; 13, glandular branches of lacrymal; 14, communicating branches of lacrymal.

The periosteum of the roof of the orbit is now exposed. This membrane is in general loosely attached; behind it is continuous with the dura mater, which at the optic foramen enters the orbit as a sheath round the optic nerve; here it divides into two layers, one of which is continuous with the periosteum, the other is thecal, and is continued along the optic nerve to the eye. The periosteum entering the sphenoidal fissure becomes continuous with the first-named periosteal layer.

By dividing the periosteum longitudinally the subperiosteal layer of fat is exhibited, and at the anterior orbital margin the attachment of the tarsal membrane to it is shown. It can now be seen that the periosteum becomes very strong and thick over the frontal process of the jugal bone, where it is joined to the external palpebral ligament. If the temporal fossa has been fully dissected it is of advantage to remove the outer wall of the orbit as well, as far down as the level of the upper edge of the zygoma.

Within the orbit are to be found (A) seven voluntary muscles and several sets of unstriated fibres; (B) the distribution of the second, third, fourth, ophthalmic branch of the fifth, and sixth nerves; (C) the ophthalmic vessels; and (D) the lacrymal gland. These are appendages of the great central organ of the cavity, (E) the eyeball.

The order of the nerves entering the orbit has been already seen in dissecting the dura mater, and the frontal branch of the fifth (fig. 715, 5) is conspicuous below the periosteum, together with the supraorbital artery and vein (figs. 722, 723). In the sphenoidal fissure the fourth nerve is the highest, then the frontal branch of the fifth, followed by the superior division of the third nerve, the lacrymal (externally), and the nasal (internally), the inferior division of the third, the sixth nerve, and the ophthalmic vein is the lowest of all.

518. THE FRONTAL BRANCH OF THE OPHTHALMIC NERVE lies in the orbit beneath the periosteum, and is crossed by the fourth (fig. 715, 3) as it is rising above the origin of the *levator palpebrae* muscle. It passes forwards on this muscle, and at the hinder third of the orbit divides into two branches, **supraorbital** and **supratrochlear**. The supraorbital or continued trunk passes straight to the supraorbital notch, having its companion blood-vessels to its outer side. Before it escapes from the orbit it divides into a thick *outer* and a weaker *inner* branch. The former (*ib.*, 11) traverses the notch and, as it does so, sends into the bone a branch to the diploë, and one to the frontal sinus; it then ascends on the forehead, at first beneath, then piercing the ectorbital orbicularis and the frontalis muscles. It here divides into four sets of branches—(1) middle superior palpebral, distributed to the upper eyelid; (2) periosteal to the forehead; (3) superficial frontal to the skin of the bare forehead; and (4) deep frontal to the skin of the hairy scalp, easily traceable as far back as the coronal suture.

The inner supraorbital branch (*ib.*, 10) escapes internal to the last, and along with the frontal branch of the ophthalmic artery, and supplies the skin over the glabella and the median region of the brow above it, but not running above the border of the hair. It is not strained so close to the bone by the tension of ascending fibres, and therefore seldom notches the orbital edge.

The supratrochlear nerve (*ib.*, 9) passes forwards and a little inwards close to the periosteum, and escapes internal to the trochlea. Here it divides into two, a descending branch forming a loop with the infratrochlear branch of the nasal, and an ascending, which supplies branches to (1) the periosteum, and (2) the skin of the lower part of the glabella, (3) the root of the nose below it, and (4) the inner part of the upper eyelid (internal palpebral). The trochlear loop from its convexity gives branches to the inner canthus and the shores of the lacrymal lake.

519. THE LACRYMAL NERVE (*ib.*, 6) passes close to the periosteum along the upper and outer edge of the external rectus muscle to the hinder border of the lacrymal gland, which it traverses, sending branches—(A) to the gland (*ib.*, 13); (B) to the conjunctiva of the external canthus; (C) to the upper eyelid (external superior palpebral—*ib.*, 12). Before reaching the gland it gives off an inferior

branch which descends on the lateral wall of the orbit, and enters a canal in the periosteum over the malar bone, wherein it forms a loop with the subcutaneous malar nerve. Branches from this loop pass to both parts of the lacrymal gland (*ib.*, 14). Stimulation of either stem of this loop causes lacrymation, division causes the pouring forth of a paralytic secretion. The lacrymal represents the visceral nerve of the premandibular segment.

520. ORBITAL MUSCLES.—The muscles within the orbit are in three sets. (I.) There are four *recti* arranged around the optic nerve, and called from their positions *superior*, *inferior*, *external*, and *internal*, these recti arise around the optic nerve and they are inserted into the sclerotic coat of the eyeball in front of the equator of the eyeball. (II.) The *oblique* muscles are two, *superior* and *inferior*; (III.) the last muscle is the *elevator of the upper lid*. Of these muscles the *superior oblique* is supplied by the fourth nerve, the *external rectus* by the sixth, and the others by the third.

The origins of the recti spring from an elliptic fibrous ring of thickened periosteum, which surrounds the optic nerve. This is prolonged below as

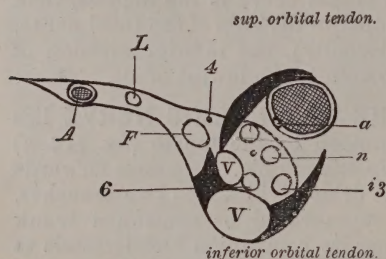


Fig. 716.—Scheme of relations of the origins of the recti muscles to the orbital vessels and nerves—*A*, lacrymal branch of middle meningeal artery; *L*, lacrymal nerve; *F*, frontal; *n*, nasal; *V*, *V'*, ophthalmic veins; *a*, ophthalmic artery; *4*, fourth nerve; *i3*, inferior division of the third; *6*, sixth nerve. The long root of the ciliary ganglion is represented as a dot external to the nasal nerve, and the superior division of the third is directly above this. The line from *6* crosses the origin of the external rectus from the alisphenoid.

rectus and the upper parts of the *inner* and *outer recti* are attached. From the three slips of the inferior tendon the *inferior rectus* and the lower parts of the *inner* and *outer recti* arise. The tripartition of the slips is really due to the projection of ridges of tendon into the muscular origins, which are clothed by fleshy fibres on both sides.

Llevator palpebræ superioris (fig. 723, 2) arises by a slender tendon, above the *rectus superior*, from the periosteum of the orbito-sphenoid, above and in contact with the superior palpebral tendon. It passes forwards, becoming fleshy and widening, to form an elongated triangle lying beneath the orbital roof and the frontal nerve and artery and lying upon the *superior rectus* (fig. 715). It becomes tendinous as it reaches the anterior orbital opening and enters the substance of the upper lid; here its aponeurotic tendon sends off an *anterior layer* of fibres; these pierce the fibres of the tarsal membrane and are inserted into the hinder margin of the superior tarsal body and by scattered fibres into the sheath of the *palpebral* muscle and skin of the eyelids; a deeper plane of fibres sinks to

a tendinous bridge over the lower and inner part of the sphenoidal fissure to a little spur on the great wing of the sphenoid, the *spina recti externi*; from this a second bridge spans the upper part of the fissure to the thin edge of bone between the optic foramen and the sphenoidal fissure. The lower margin of this ring is elongated forwards into a flattish expansion; this appears when viewed on its upper side, which is turned towards the optic nerve, to divide into three slips. The expansion is called the **tendo orbitalis inferior** of Zinn. Above, there is an indistinct elongation of the same kind also appearing on its neural side as tripartite, this is the **tendo orbitalis superior** of Lockwood. Both are but specialised parts of the elliptic ring, and the upper is the more indistinct: the lower is well-marked, on account of its relation to the fissure. To the three slips of the superior tendon, the *superior*

be inserted into the conjunctival side of the tarsal body and the fornix superior, between these layers is the palpebral layer of smooth muscle attached to the tarsal body from the *levator tendon* (fig. 713). At each angle of the lid the fibres become indistinct, but are continued forwards into the inner and outer palpebral tendons, and by part of the inner angular prolongation it is attached to the lower and hinder edge of the trochlea of the *superior oblique* muscle which it thus serves to make tense.

This muscle is supplied by the superior division of the third nerve and the superior muscular artery; it has arisen as a differentiation of the upper peripheral part of the superior rectus. Traces of the original connection sometimes survive.

Divide this muscle at its origin and throw it forwards, exposing under it

Rectus superior (fig. 717, 8), the longest but weakest of the quartet, which arises from the superior orbital tendon closely connected with the internal and upper part of the *external rectus* and with the last; it passes forwards beneath the *levator palpebrae superioris*, on the outer side of which, however, more than half of its surface is uncovered. It lies on the orbital fat which covers the optic and the nasal nerves, the ophthalmic artery and vein, the capsule of Tenon, and the eyeball. Its insertion is—(1) by a tendon 5 mm. long into the sclerotic 7.5 mm. from the corneal border, the line of insertion being 7 mm. broad and convex

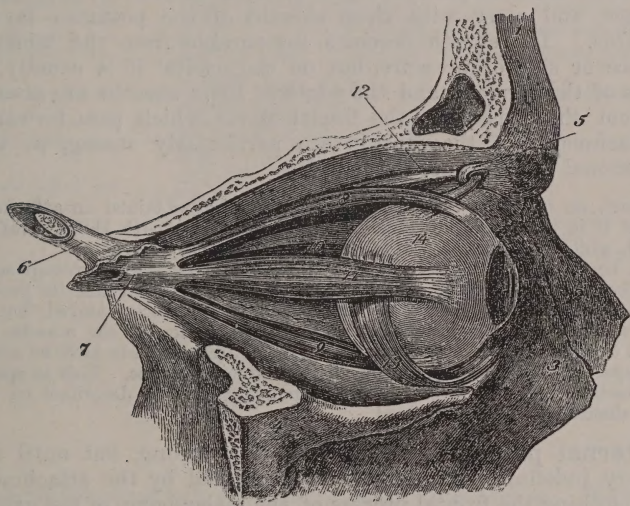


Fig. 717.

forwards. (2) By an expansion from its sheath into the subconjunctival tissue close to the fornix and into the tarsal body along with the deep fibres of the *levator*. It raises the eye and, by virtue of the palpebral attachment of its sheath, it lifts the lid in sympathy with the uptilting of the eyeball. The *superior recti* of the two sides always act together.

Divide the superior rectus where it is becoming tendinous as it lies on the eyeball, and reflect it backwards. The superior branch of the third nerve can be seen entering it and the foregoing muscle on their ocular surfaces, the branch to the latter passes on the outer side of the superior rectus. Beneath the tendon of this muscle the following parts are shown:—

I. The Intermuscular Cone of Fat (fig. 718).—This is a more or less compact and definitely organised cone of large soft-grained fatty tissue, which forms a continuous mass beneath the muscles, and which is traversed by some

of the vessels and nerves. Its anterior surface is smoothly concave to fit the eyeball, and is clothed with the following membrane:—

II. The Capsule of Tenon.—This is a strong, smooth areolar tissue, whose aspect has been aptly compared to the tunica vaginalis, and which lies behind the eyeball. It may be regarded as composed of two layers, a posterior clothing the front of the fatty cone, and an anterior clothing the hinder surface of the eyeball, and separated from the former by a potential space (the space of Tenon), the walls of which are in contact during life. The posterior surface of Tenon's capsule is attached by numerous areolar processes to the interstitial tissue of the fatty cone, so as to be closely tied thereto. Around the optic nerve the fascia is strengthened into a fibrous ring, from which a very delicate areolar layer is continued backwards as a sheath around the nerve, bounding around it a **perineural space**, wherein the ciliary nerves and vessels make their way forwards. Peripherally, the ocular layer of the capsule of Tenon is traceable forwards over the back and sides of the eyeball, and becomes lost above and below by uniting inseparably with the subconjunctival areolar tissue at the fornix superior and inferior; laterally, it extends around the sclerotic as far as the external and internal palpebral ligaments, with which it also becomes blended.

As the recti tendons pass forwards to their insertions, they project into Tenon's space, and carry with them sheaths of the posterior layer of this fascia forwards. The sheath becomes inseparable from the tendon on the ocular surface or side of pressure, but on the orbital it is usually separable. The margins of the tendons and the edges of their sheaths are always closely united. From these margins, the fascial fibres which pass forwards to the anterior attachments of the capsule are particularly strong, so that these become functional insertions of the muscles.

It is by such an insertion that the *superior rectus* has obtained an attachment to the upper lid, and it is the sundering of a slip of that muscle with this lateral connection hypertrophied, which has given rise to the *levator palpebræ superioris*.

It must be borne in mind that, with one exception, these fascial arrangements are the creations of the muscular action, and that the capsule of Tenon and its processes were originally the continuous areolar atmosphere wherein the muscles moved, but that their actions have specialised the various slips whereby the action of the muscles is aided or corrected, and that consequently these various fibrous arrangements have no morphological existence as separate units independent of their producing causes. This is specially to be noted in connection with the two palpebral ligaments already described on their facial aspect; these should now be re-examined.

The external palpebral tendon is very strong, but until artificially dissected, very indefinitely bordered. It is formed by the attachment to the periosteum, clothing the frontal process of the malar bone, of the external ends of the tarsal membranes, here thickened so as to form the outer fixed point of the tarsal bodies. To the front of this the palpebral muscle and skin is attached, to the lateral margin the tarsal membranes, to the deep surface the outermost fibres of insertion of the *levator palpebræ superioris*, a strong outer portion of the capsule of Tenon, and the sheath of the tendon of the *external rectus*. It serves to fix the external canthus, and by its attachment to Tenon's capsule it acts as a strong ligament to keep the eyeball from being retracted by the *recti*.

The inner palpebral tendon is more completely specialised on account of its relation to the derivative lacrymal apparatus. The orbital periosteum at the crista lacrymalis splits into two layers, one keeps close to the bone while the other passes over the lacrymal sac, and is pierced by the canaliculi. As this layer passes forwards it becomes attached to the tarsal membranes, and medially, is strengthened by having the inner ends of the tarsal bodies attached thereto. This causes the middle portion of this layer to project

forwards as an oblique ridge, above and below which the fibres of the *orbicularis* are attached, so the intermediate ridge which comes to the surface appears as a cord and is called the internal *tendo palpebrarum*, appearing, but not really being, more distinct than the much stronger outer tendon. To this also the inner angle of the fibres of the *levator palpebræ* and the sheath of the *internal rectus* muscle are attached.

The **superior oblique muscle** (fig. 717, 12), which can now be traced, is remarkable as being the remains of a cephalic muscle-plate otherwise unrepresented. It arises from the orbito-sphenoid 2 mm. above and internal to the *superior rectus*, and passes forwards beneath the inner part of the orbital roof towards the internal angular process; here it becomes tendinous, and the tendon passes through a small curved tubular pulley and bends suddenly backwards, outwards, and downwards at an angle of 30° . The tendon is

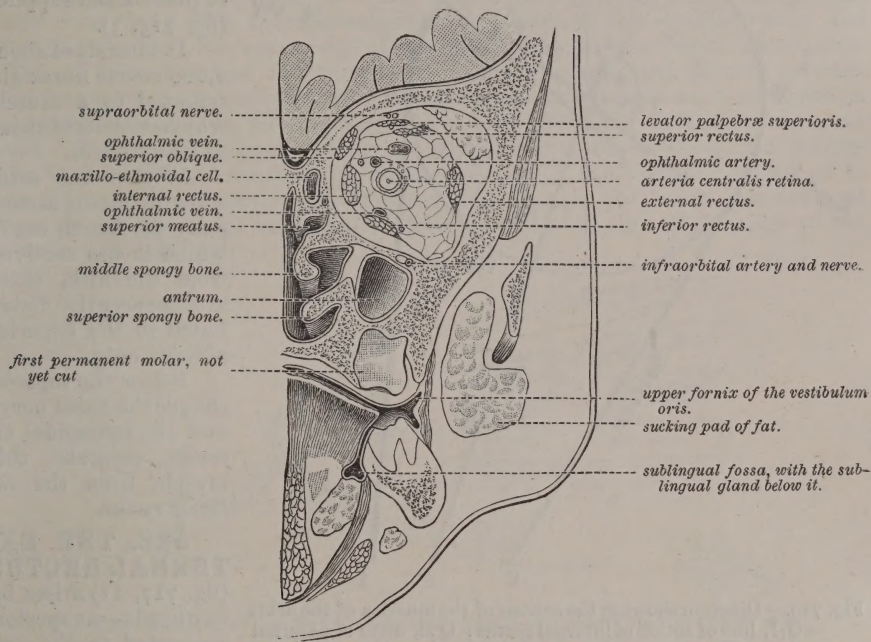


Fig. 718.—Coronal section of right side of face of boy of six years of age. The lacrymal gland is crossed by the dotted lines to the levator and superior rectus. The perineural space, with the ciliary vessels and nerves therein contained, and the organisation of the fatty cone, are also shown.

prolonged over the sclerotic, beneath the superior rectus, piercing and carrying with it an oblique expansion of Tenon's capsule to be inserted into the sclerotic at the level of the equator oculi, in the interval between the *superior* and the *external rectus*.

The **trochlea** is made up of a fine grooved plate of hyaline cartilage 4 mm. long by 6 broad, curved into a tube wherein the tendon lies. The edges of the cartilage are tied to the trochlear fossa of the frontal by the fibrous **retinacula trochleæ**, which complete the tube. The tendon here is invested by a very lax laminated areolar tissue with an imperfect endothelial lining in its clefts, but there is scarcely ever a true synovial membrane lining the trochlea. The reflected tendon is invested in a loose sheath, derived from Tenon's fascia, and is nearly 20 mm. long.

This muscle has its metameric nerve, the fourth, lying on its upper surface, and is separated from the contiguous muscles by a distinct, but very thin, intermuscular septum, wherein

the nasal nerve lies for part of its course. The trochlea is the specialised margin of this septum, and was primitively the sheath of the muscle at its origin; but the need for a longer belly in mammals has led to the development of a pulley, and the retrocession of the origin which has travelled backwards along the inner side of the orbit, hence the linear extent of the bony origin is variable.

521. THE FOURTH NERVE (§ 514) enters the orbit above the frontal branch of the fifth, and having emerged from its canal of dura mater crosses the

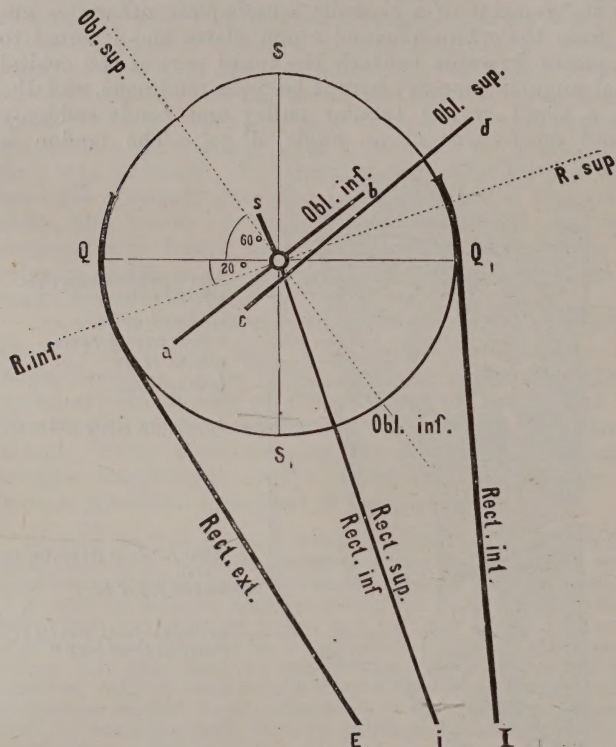


Fig. 719.—Diagram showing the actions of the muscles of the orbit—Q₁I, line of action of internal rectus; Q₁E, ditto of external rectus. These rotate the eyeball in the plane of the diagram, around a vertical central axis, O; R. sup., R. inf., the two ends of the dotted line representing the axis around which the superior and inferior rectus rotate the eyeball, forming an angle of 20° with the axis Q₁Q. These recti retract the eyeball along the line s₁i. The axis of rotation of the two oblique muscles lies in the dotted line Obl. sup., Obl. inf., and forms an angle of 60° with the axis Q₁Q. Both these latter axes lie in the horizontal plane of bisection of the eyeball. The superior oblique draws the eyeball along the line c₁d, the inferior along the line a₁b. These are the displacements of the eyeball from the neutral plane of rest.

origin of the *levator palpebrae superioris* to lie on the upper surface of the *superior oblique* muscle, which after a short course it pierces and supplies (fig. 715, 3).

It consists of about 2,000 coarse fibres distributed to a muscle which consists of about as many fibres.

Within the orbit a few filaments accompany the fourth nerve which it has received from the fifth, these are apparently distributed to the superior oblique only.

Below the *superior oblique* the nasal nerve and the ethmoidal arteries separate this muscle from the *inferior rectus*.

522. THE EXTERNAL RECTUS (fig. 717, 11) arises by two heads—a superior, connected to the origin of the *superior rectus* and arising from the superior orbital tendon and the periosteum of the thin ridge of bone between the optic foramen and the sphenoidal fissure; the inferior head arises from the part of

the inferior orbital tendon, which bridges the lower part of the sphenoidal fissure between the tendon of the inferior rectus and the spina recti externi on the great wing of the sphenoid. Between these two heads the inferior division of the third, the nasal, and sixth nerves, and the ophthalmic vein, pass. The muscle extends forwards, diverging at an angle of 60° from its fellow of the opposite orbit, and is inserted by a tendon 4 mm. long into the

sclerotic, 7.5 mm. from the corneal edge. The line of tendinous insertion is 6 mm. long, and convex forwards.

The *external rectus* is supplied on its ocular surface by the sixth nerve. It has on its inner side the fatty cone and the capsule of Tenon, the ciliary ganglion, the ophthalmic artery, and nasal nerve.

523. THE SIXTH NERVE enters the orbit internally through the sphenoidal fissure, passes between the heads of the *external rectus*, and is distributed to its substance. It consists of about 2,000 large fibres, and is distributed to a muscle which contains about 5,000 fibres. In the orbit it neither receives nor gives any communicating branches.

524. THE NASAL BRANCH OF THE OPHTHALMIC NERVE (fig. 715, 7) enters the orbit between the heads of the *external rectus*, and passes obliquely inwards and forwards over the optic nerve, first beneath, then through, the fatty cone along with the ophthalmic artery, beneath the *superior rectus*, and then passes above the upper edge of the *internal rectus* and below the *superior oblique*. Here it enters the anterior ethmoidal foramen, and passing between two fronto-ethmoidal cells, enters the cranial cavity external to the cribriform plate, which it crosses, passing forwards to sink through a slit beside the crista galli. In the nose it passes along the sulcus olfactorius forwards, and divides into three terminal branches—(1) to the mucosa of the septum; (2) lateral to the mucosa of the atrium and agger; (3) cutaneous, which first grooves and then pierces the nasal bone, and is distributed to the skin of the ridge of the nose as far as the tip.

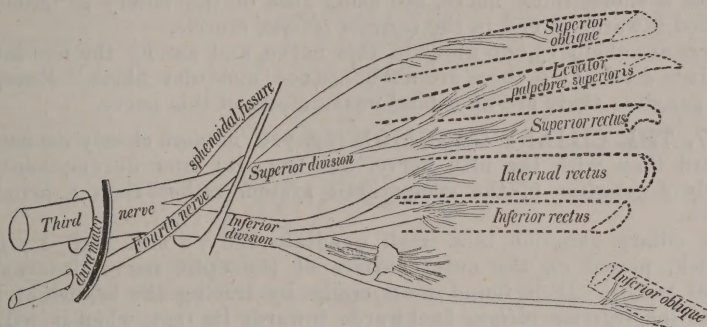


Fig. 720.—Scheme of the distribution of the third and fourth nerves in the orbit.

As the nasal nerve enters the orbit it gives off (1) the long root of the ciliary ganglion, about 1 cm. long, which passes along the outer surface of the optic nerve. (2) Farther forward it sends off long ciliary branches, which run on the inner side of the optic nerve, traverse the sclerotic, to end within the eyeball (p. 670). (3) Before it enters the ethmoidal hole it gives off a minute filament into the posterior ethmoidal foramen, which is lost in the mucosa of the posterior fronto-ethmoidal cells (*nervulus sphenothmoidalis*).

As it enters the anterior ethmoidal hole it gives off the infratrochlear nerve which escapes below and internal to the trochlea, with the nasal branch of the ophthalmic artery. This sends off an ascending branch to form the trochlear loop with the supratrochlear (p. 649), and a descending to the plica semilunaris and conjunctiva of the inner canthus.

The nasal is the nerve of the margin of the fronto-nasal lobe, derived from the suprabranchial nerve of the premandibular segment.

Dividing the *superior oblique* directly behind the trochlea and reflecting it backwards, the *internal rectus* is shown.

525. INTERNAL RECTUS (fig. 717, 10), the longest and largest of the series, arises on the inner side of the optic nerve from the inferior orbital tendon, and by a few fibres from the superior tendon. It passes forwards, nearly parallel to its fellow, to be inserted by a tendon, 8 mm. long, into the sclerotic 7 mm., from the corneal edge, by a line of insertion about 8 mm. long and concave forwards. Above its upper edge lies the nasal nerve and ethmoidal arteries, and the terminal branches of the ophthalmic artery. It is supplied by the inferior division of the third nerve, and the inferior muscular branch of the ophthalmic artery.

526. THE THIRD NERVE (fig. 720) has been already seen (p. 647) to divide in the dura mater of the outer wall of the cavernous sinus into two branches—a smaller superior and a larger inferior. The superior division enters the sphenoidal fissure below the frontal and above the nasal nerves; it lies usually between the heads of the *external rectus*, and ascends over the optic nerve and ciliary ganglion to the under surface of the *rectus superior*, and passing the outer edge of this muscle to the under side of the *levator palpebrae superioris*.

The inferior branch passes also between the heads of the *external rectus*, and divides into three branches:—(1) for the *internal rectus*; (2) for the *inferior rectus*; and (3) for the *inferior oblique*.

The two former pass beneath the optic nerve inwards to their respective muscles. The last passes forwards between the inferior and the external rectus outside and below the optic nerve; as it passes the hinder fourth of this, it gives off a short, thick nerve, the short root of the ciliary ganglion, and is continued inwards to end in the *inferior oblique* muscle.

There are about 15,000 fibres in this nerve, and among the five muscles to which it is distributed there are about 40,000 muscular fibres. Except in the ciliary ganglion there are no orbital anastomoses of this nerve.

527. THE CILIARY GANGLION (fig. 720) is more closely connected with the third than with the fifth nerve, but from its later development is more probably a ganglion of the sympathetic system rather than a primary root ganglion.

The ciliary ganglion is a small quadrate body, 2 mm. high, 1·7 long, and 0·6 thick, placed on the outer surface of the optic nerve, internal to the external rectus. It is found most easily by tracing the branch of the third nerve to the *inferior oblique* backwards towards its root, when it will be seen to lie directly above this nerve on a level behind the point where the ophthalmic artery crosses the optic nerve.

Into its upper and hinder angle passes the long root from the nasal nerve, into its lower hinder angle the short, thick root passes from the nerve to the *inferior oblique*, and into its hinder border about four very fine filaments from the cavernous plexus of the sympathetic.

From the front border of the ciliary ganglion about six short ciliary nerves arise. These pass forwards in the perineural space, and each divides into several branches, so that when they reach the eyeball there are about twenty nerves, of which one large set is above and external, a second set below and internal.

They pierce the sclerotic and then enter the eyeball (p. 670).

528. THE OPHTHALMIC ARTERY (figs. 721, 723) arises from the anterior convex surface of the fourth curve of the internal carotid as it emerges through the dura mater beneath the anterior clinoid process. It enters the orbit through the optic foramen beneath the nerve, and, piercing the enveloping sheath of dura mater, passes at first outwards, and lies between the *external rectus* and the optic nerve below the nasal nerve. It thence ascends tortuously (even in the child),

forwards and inwards, crossing over the optic nerve beneath the *superior rectus* and in front of the nasal nerve. Having reached the inner side of the optic nerve, it passes forwards between the *superior oblique* and the *internal rectus* to terminate by bifurcating beneath the trochlea.

Shortly after its entrance into the orbit it sends off a short inferior branch, usually of small size, which passes beneath the optic nerve to its inner side and divides into two.

1. **The arteria centralis retinae**, which enters the outer side of the optic nerve, in the axis of which it passes forwards to the retina (p. 659).

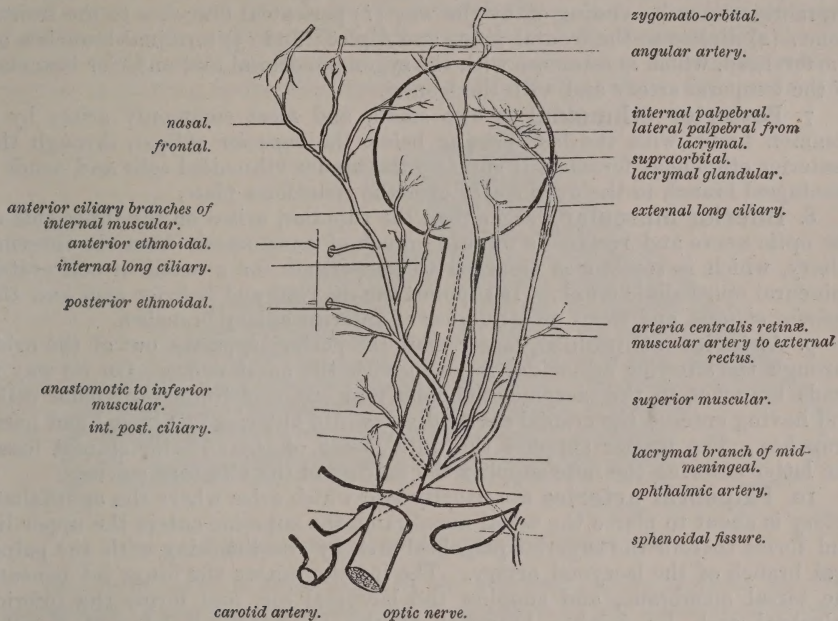


Fig. 721.—Scheme of course and branches of the ophthalmic artery.

2. **The internal posterior ciliary stem.**—This passes forwards and inwards, and subdivides in the perineural space into six or seven branches which pierce the sclerotic; one of these is usually larger and pierces a little farther out than the rest (internal long ciliary), another usually anastomoses with the internal muscular artery.

From the trunk of the ophthalmic, external to the optic nerve, the following branches arise:—

3. **External posterior ciliaries**, three or four stems, which pass forwards along the optic nerve. These divide as they approach the sclerotic, so that about six or seven vessels usually pierce that membrane. One of these, the external long ciliary, can sometimes be distinguished. There are in all about twelve or thirteen ciliary arteries piercing the sclerotic (fig. 733).

4. **Lacrymal artery** arises between the *external* and the *superior rectus*, external to the optic nerve, and passes forwards close to the periosteum along with the lacrymal nerve. Near its origin it sends a recurrent branch through the dura mater of the sphenoidal fissure, which anastomoses with the external receptacular branch of the internal carotid, and still farther outward it receives a large branch through the highest and outmost part of that fissure from the middle meningeal. This branch varies inversely in size with the lacrymal

itself. It sends off (1) muscular branches to the *external rectus*; (2) zygomatic branches accompanying the lacrymal loop of nerves; (3) glandular branches to the lacrymal gland; and (4) lateral palpebral to the outer part of the upper eyelid.

5. **Superior muscular** arises, either independently or by a common stem with the last, under the edge of the *superior rectus*. It passes forwards and supplies the *superior rectus*, *levator palpebræ superioris*, and the *superior oblique*; it sends forwards anterior ciliary branches which supply the eyeball (fig. 733).

6. **Supraorbital**, usually a very small branch, arises on the inner side of the *superior rectus* over the optic nerve, it accompanies its nerve through the supraorbital notch, sending off by the way (1) periosteal branches to the frontal bone; (2) diploic to the frontal sinus and diploë; and (3) terminal branches on the forehead, which anastomose with the zygomato-orbital and anterior branches of the temporal artery and with the frontal.

7. **Posterior ethmoidal** is also small, and most commonly arises by a common trunk with the last, passing below the *superior oblique*, through the posterior ethmoidal foramen, it supplies the hinder ethmoidal cells and sends a meningeal branch to the dura mater over the cribriform plate.

8. **Inferior muscular**, larger than the superior, arises on the inner side of the optic nerve and receives a minute branch of anastomosis from the internal ciliary, which is sometimes enlarged to compensate for a small or obliterated epineural ophthalmic trunk. It supplies the *internal* and *inferior recti* and the *inferior oblique*, and sends off a number of anterior ciliary branches.

9. **Anterior ethmoidal**, larger than the posterior, passes out of the orbit through the anterior ethmoidal foramen with the nasal nerve. On its way it sends branches to the lacrymo-ethmoidal and anterior fronto-ethmoidal cells, and having entered the cranial cavity divides into anterior meningeal and nasal branches. The former supplies the dura mater of the anterior cranial fossa, the latter entering the nose supplies the mucosa of the olfactory sulcus.

10. **Palpebral arteries** are usually two which arise where the ophthalmic artery is about to pierce the tarsal membrane, the superior enters the upper lid and forms therein the superior palpebral arch by anastomosing with the palpebral branch of the lacrymal artery. The inferior enters the lower lid beneath the tarsal membrane, and supplies the lacrymal sac, and forms the inferior palpebral arch by joining branches of the transverse facial and angular arteries.

The terminal branches of ophthalmic artery are :—

11. **Frontal** (fig. 723, 18), which escapes close to the internal frontal nerves, external to the trochlea or else with the next, and is distributed to the brow, anastomosing with the supraorbital and with its fellow.

The **dorsalis nasi** (*ib.*, 19) escapes through the tarsal membrane over the *tendo palpebrarum internum*, sends an ascending branch to join the last and its fellow over the root of the nose, but for the most part descends and supplies the dorsum of the nose, anastomosing with the angular and lateral nasal branches of the facial artery (*ib.*, 32). It supplies the lacrymal sac.

529. THE SUPERIOR OPHTHALMIC VEIN (fig. 722) is a large straight vessel, which crosses diagonally backwards and outwards from the inner canthus to the sphenoidal fissure. It begins in a small plexus near the inner canthus, whose branches pass respectively to the facial and transverse facial veins, and as it passes backwards lies anterior and superficial to its artery, and receives superior muscular, ciliary, ethmoidal, and lacrymal branches. It leaves the orbit by passing below the sixth nerve between the heads of the *external rectus*, and empties into the cavernous sinus. The blood of the terminal and other extra-orbital branches of the ophthalmic artery is not returned by this channel.

Below the optic nerve there is a smaller **inferior orbital vein**, which is formed by the veins from the lower ciliary and inferior muscular arteries, it communicates through the speno-maxillary fissure with the pterygoid plexus, but sends a small branch backwards to the cavernous sinus.

530. THE OPTIC NERVE (p. 693) for its second stage is somewhat sigmoidally curved in its course from the optic foramen to the back of the eyeball, its hinder part being concave downwards and outwards, its fore part being concave inwards. It is not quite in the axis of the orbit, but a little to its inner side. The nerve shows also a small degree of torsion.

The sheath of dura mater which passes in with it through the optic foramen is prolonged as a firm fibrous sheath as far as the eyeball, where it is continuous with the sclerotic, and it is also continuous around the foramen with the periosteum of the orbit, so there is around the nerve as it enters the orbit an angular engirdling recess, from the periosteal side from which the muscles arise.

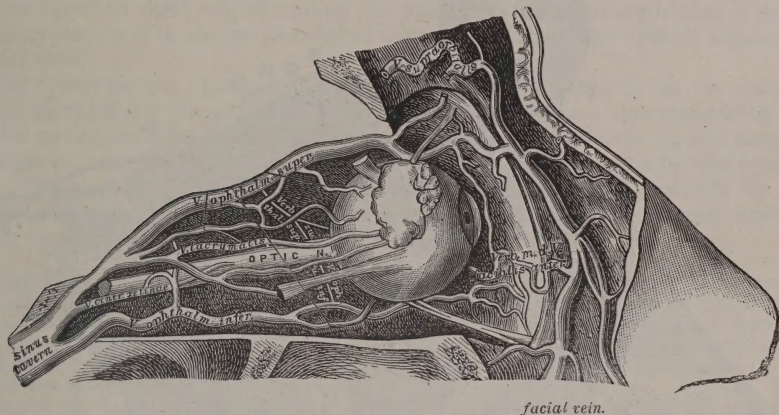


Fig. 722.—Dissection of the injected orbital veins.

The optic nerve is surrounded by the perineural space in which the ciliary nerves and vessels pass forwards, and is separated by the intramuscular cone of fat from the four *recti*. Externally, the nasal nerve, ciliary ganglion, ophthalmic artery and vein, and the sixth nerve, intervene between it and the *external rectus*. Above, the nasal nerve, ophthalmic artery and vein similarly separate it from the *superior rectus*, and below, the inferior division of the third underlies it, as it is related to the *inferior rectus*. The intraorbital stage of the nerve is about 26 mm. long, and is enveloped under the dural sheath by a fine layer, the arachnoid sheath, separated by a subdural lymph space from the overlying, and by a subarachnoid lymph space from the underlying, envelope. The latter or pial sheath sends in processes which tie the component bundles of fibres of the nerve, 800 or thereabouts, together. In a central canal enclosed in a thickening of the processes of this sheath, the central vessels of the retina pass forwards. The presence of this central mass of the pial sheath differentiates the last cm. of the nerve. The nerve contains about 400,000 fibres of estimable size, and many extremely minute filaments in their interspaces.

Divide the ophthalmic vessels as they cross the optic nerve and reflect them. Divide the optic nerve at its entrance into the orbit and draw it forwards, remove the fat below the nerve, and so expose the inferior division of the third nerve, and the *inferior rectus* muscle.

531. THE INFERIOR RECTUS arises by the middle slip of the inferior orbital tendon from the periosteum below the optic foramen. In length it is

the shortest and in bulk the third of the recti, and it is inserted by a tendon 5.5 mm. long into the sclerotic, 7 mm. behind the corneal edge, and its line of insertion is 6 mm. long, and nearly straight, equidistant between the internal and external recti. The capsule of Tenon sheathing the tendon is laterally and firmly attached to the tendon and prolonged into the lower lid, in front of the tarsal body, and is attached by a deep series of fibres into the fornix palpebræ inferioris. From this expansion arise unstriated fibres which form a lamella in the lower lid attached to the edge of the tarsal body, the *musculus palpebralis inferior*.

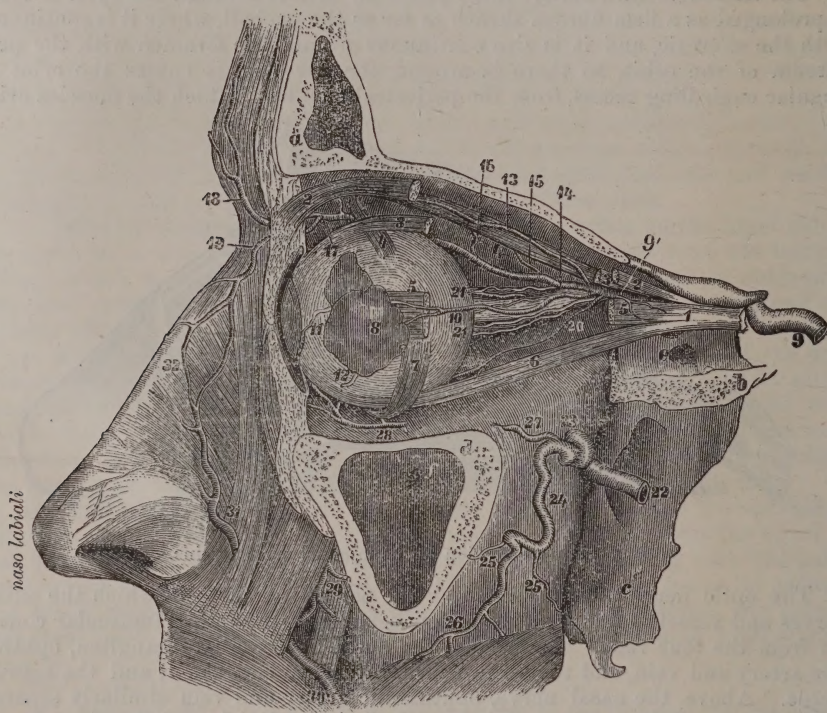


Fig. 723.—Orbit opened from the outer side showing the ophthalmic artery and its branches—1, origin of recti; 2, levator palpebræ superioris cut; 3, superior rectus; 4, superior oblique; 5, external rectus; 6, inferior rectus; 7, inferior oblique; 8, lacrimal gland; 9, carotid artery; 9', ophthalmic artery; 10, lacrimal artery; 11, palpebral artery; 12, inferior lacrimal duct; 13, supraorbital artery; 14, long ciliary; 15, 16, ethmoidal arteries; 17, bifurcation of ophthalmic artery; 18, frontal artery; 19, nasal; 20, inferior muscular; 21, short ciliaries; 22, internal maxillary; 23, its fourth stage; 24, alveolar; 25, dental; 26, gingival branch; 27, 28, 29, infraorbital; 30, 31, facial; 32, lateral nerve.

Dissection.—Divide the inferior tarsal membrane at its infraorbital attachment and raise the eyeball. The inferior oblique is brought into view arising at the front of the orbit from a pit in the superior maxillary bone behind the orbital brim, and external to the hamulus lacrymalis. From its short tendon of origin its small fleshy belly passes backwards, outwards, and a little upwards, its course intersecting the axis of the orbit at an angle of 75° , and it is inserted into the sclerotic between the superior and the external recti in a zone nearer to the optic nerve than that of the insertion of the superior oblique.

As it lies in the orbit it is a flat band with its surfaces directed upwards and downwards respectively, and its insertion is broad in the horizontal meridian of the eyeball. Its nerve enters its hinder border about its mid point.

In the neutral or *primary position* of the eyeballs, the **visual axis**, which

passes through the most prominent spot of the cornea and the fovea centralis of the retina, is in a horizontal plane, but owing to the greater size of the *internal rectus* this visual axis converges with that of its fellow about 40 cm. in front of the eye.

All motions of the eyeball take place around a **point of rotation** situated 177 mm. behind the centre of the visual axis (fig. 719, S S¹). The visual axis of the two eyes lie in a plane, the **visual plane**, whose hinder limit is a line joining the two centres of rotation. The transverse axis (fig. 719, Q Q¹) is the horizontal co-ordinate of this system, and the vertical axis is at right angles to the diagram. The eyes can be raised until the visual plane in its secondary position forms an angle of 34° with its level in the primary position. They can be depressed to an angle of 57°. They can be turned outwards through 42° and inwards through 45°.

When the eye is in a secondary position, up or down, out or in, and is then made to move at right angles around the altered axis, the new position is called a tertiary one, and is always associated with a rotation of the eyeball around its sagittal axis.

The eye is turned outwards by the *external rectus*; inwards by the *internal rectus*; upwards by the *superior rectus* and *inferior oblique*; downwards by the *inferior rectus* and the *superior oblique*; upwards and outwards by the *external* and *superior recti* and *inferior oblique*; downwards and outwards by the *inferior* and *external recti* and the *superior oblique*; upwards and inwards by the *internal* and *superior recti* and the *inferior oblique*; downwards and inwards by the *internal* and *inferior recti* and the *superior oblique*.

Dissection.—The contents of the orbit having been cleaned out, the **musculus orbitalis** is exposed as a layer of unstriped fibres overlying the membrane which closes the speno-maxillary fissure. This muscle consists of fibres passing obliquely from the maxillary to the sphenoidal edge of the membrane, and extending upwards on the sphenoid, especially in front. It is nearly 1 mm. thick for the middle third of the space, but is thinner in front and behind.

Remove the bridge of bone which separates the foramen rotundum from the sphenoidal fissure, and break through and remove the lamella of bone which overlies the infraorbital canal. Thereby the maxillary nerve is exposed.

532. THE MAXILLARY NERVE (superior maxillary) arises from the front of the Gasserian ganglion (fig. 724), and passes forwards in a canal of dura mater to escape through the foramen rotundum. It is larger than the ophthalmic, but smaller than the inferior maxillary. Its course is divisible into three parts—intracranial, speno-maxillary, and infraorbital.

The intracranial stage (*ib.*, 1) is about 1 cm. long, and is directed horizontally forwards, and as it is about to leave the cranium it gives off two fine branches to the dura mater, chiefly passing along the line of the middle meningeal artery. These form loops with the inframaxillary meningeal nerves.

The maxillary nerve in the foramen rotundum enlarges, and becomes looser in texture, and passes outwards and forwards obliquely in the speno-maxillary fossa towards the speno-maxillary fissure, through which it enters the orbit. In this part of its course it lies above the terminal branches of the internal maxillary artery, and above and internal to the *external pterygoid* muscle.

In this stage the nerve sends (1) downwards at right angles a soft, often divided, **spheno-maxillary** branch into the pterygo-maxillary fossa. This, on the outer side of the speno-palatine foramen, enlarges and forms the speno-maxillary, or Meckel's ganglion (*ib.*, 3). (2) From its outer and upper surface it sends the **orbital** branch (*ib.*, 2), which enters the orbit through the speno-maxillary fissure, and there divides into two branches, one of which passes through the temporal, the other through the malar canals in the malar bone.

The temporal branch sends a branch to form the lacrymal loop with the lacrymal nerve; and having traversed the bony canal, it escapes at the hinder border of the temporal surface of the malar bone, pierces the temporal fascia, to be distributed to the skin over the frontal part of the temporal region.

The malar branch escapes on the facial surface of the malar bone, and is distributed to the skin of the cheek.

(3) The **posterior alveolar nerve** (*ib.*, 4), often double, arises as the trunk is about to enter the orbit, and descends on the tuber maxillare; here it gives off an external set of branches which are distributed to the gums and neighbouring part of the cheek, *superior gingival branches*. The main stem enters the posterior alveolar foramen, and runs in a canal above the alveoli of the upper molar teeth, to each fang of which it sends a twig. This nerve gives off internal branches which enter the antrum.

The third stage of the superior maxillary nerve lies in the infraorbital canal in the maxilla, and is accompanied by the infraorbital artery. It is to be exposed by removing the contents of the orbital cavity and opening the canal.

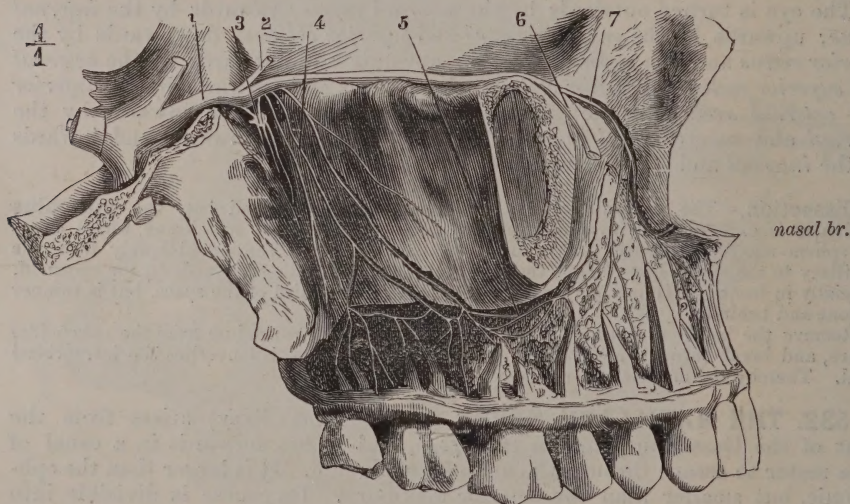


Fig. 724.—The maxillary nerve and the sphenopalatine ganglion, seen from without. The outer lamella of the alveolar arch is removed.

Shortly after its entrance this nerve sends off a **middle alveolar branch** which passes in a special canal outwards and downwards, and ends by sending branches to the premolars and canine teeth. This nerve is joined by a branch of the last over the second premolar alveolus, and forms there a slight thickening, not a true ganglion, the **pseudo-ganglion of Valentin** (fig. 724, 7). At the anterior third of the infraorbital canal a third (the **anterior alveolar**) nerve arises. This passes downwards in the anterior alveolar canal in the maxilla, along the front wall of the antrum, and divides into a series of branches distributed to the incisor teeth; one large nasal branch passes inwards, and is distributed to the mucosa of the inferior meatus. Anteriorly, where the foremost branch of the middle alveolar nerve joins the anterior, over the alveolus of the canine tooth is a second swelling, the **pseudo-ganglion of Bochdalek**, from which nerves descend to supply the canine tooth. Like the former it is not a true ganglion.

The terminal branches of the maxillary emerge as the **infraorbital nerve**

(a name sometimes given to the whole third stage) below the orbit, and here they separate into three sets of branches, which lie at first under the *levator labii superioris* and over the *levator anguli oris* (fig. 614). 1. The **ascending** or palpebral branches are two. One turns upwards and inwards, and supplies the skin and conjunctiva of the middle and inner thirds of the lower lid; a second turns outwards and upwards to supply its outer third. From the former pass perforating branches, which enter the holes of the suture notha of the maxilla, are distributed to the bone and also to the adjacent mucosa of the nose.

2. The **internal** or nasal branches are two, distributed to the skin of the ala nasi, nostrils, and philtrum.

3. The **labial** branches are four, and are the largest branches of the nerve. They end in the skin, mucosa, and prolabium of the upper lip.

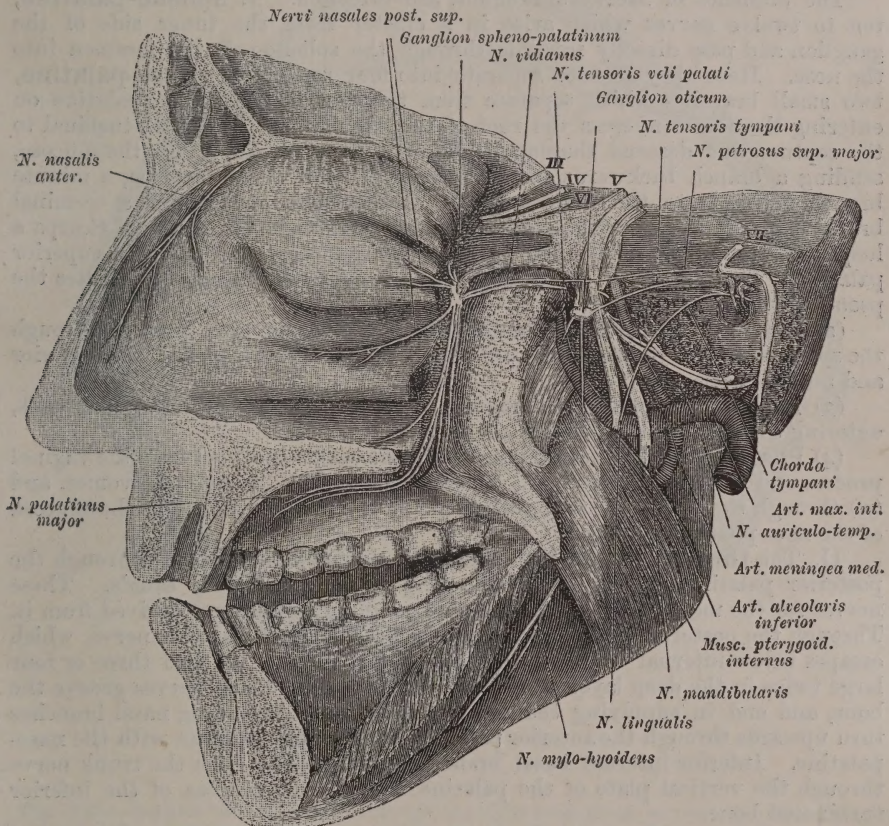


Fig. 725.—The sphenopalatine (Meckel's) and otic (Arnold's) ganglia and their relations, seen from within.

533. MECKEL'S GANGLION.—The sphenomaxillary branch, after a short vertical course, enlarges into the **sphenopalatine or Meckel's ganglion** (figs. 724, 3; 725), a small, flattened, irregularly three-sided body, with difficulty cleaned, as its branches are closely related to the terminal branches of the internal maxillary artery and are surrounded by soft fat.

Into its posterior angle passes the **Vidian nerve**, a compound trunk which passes through the Vidian canal, but which at the posterior mouth of that

canal is formed by the union of two nerves, the **great superficial petrosal**, the motor root of the ganglion, and the **great deep petrosal**. The former of these is a medullated nerve with large white fibres; the latter is a gelatinous nerve with, for the most part, non-medullated fibres, arising from the outer division of the carotid plexus, passing horizontally from the carotid canal, through the meso-cranial cartilage, to the Vidian foramen. This is the sympathetic root of the ganglion, or, rather, the continuous sympathetic cord to which the sphenopalatine and greater superficial petrosal are rami communicantes.

The great superficial petrosal has been seen within the skull as it emerges from the hiatus Fallopii and dips through the foramen lacerum anterius to the Vidian canal. This nerve contains not only motor filaments from the facial, but sensory, which possibly are recurrent from the fifth to the facial.

The branches of Meckel's ganglion are threefold. I. **Spheno-palatine**, ten to twelve nerves which arise in a cluster from the inner side of the ganglion and pass directly inwards through the sphenopalatine foramen into the nose. Here they at once separate into four series. (1) **Naso-palatine**, two small branches which separate from the rest of the sphenopalatine on entering the foramen, cross the roof of the nose below the sphenoturbinal to the septum, and descend thereupon obliquely forwards, supplying the mucosa, sending a branch backwards to the pharyngeal end of the septum, a minute branch forwards to the mucosa of the Jacobsonian organ, and a terminal branch through the anterior palatine foramen to form in the canal of Scarpa a looped communication with the nerve of the opposite side and the superior palatine. The thickened connective tissue around this nerve constitutes the pseudo-ganglion of Cloquet.

(2) **Superior anterior sphenopalatine nerves** pass inwards through the sphenopalatine foramen, and are distributed to the mucosa of the superior and middle meatuses.

(3) **Ethmoidal branches** supply most of the lateral ethmoidal cells, entering through minute holes in the bone.

(4) **Pharyngeal branches** pass in minute canals—(a.) between the vaginal process and the basi-sphenoid, (b.) between the vaginal process and vomer, and (c.) through the pterygo-pharyngeal canal. They are distributed to the mucosa of the naso-pharyngeal region.

II. The **three palatine branches** pass downwards vertically through the posterior palatine canal and the two neighbouring accessory canals. These nerves for the most part pass through the ganglion and are not derived from it. Through the posterior palatine canal descends the great palatine nerve, which escapes below internal to the alveolar arch, and breaks up into three or four large twigs in the deep layer of the palatine mucosa. These nerves groove the bone, and end in supplying the palate and gums. Ascending nasal branches turn upwards through the anterior palatine canal to communicate with the nasopalatine. Inferior internal nasal branches pass directly from the trunk nerve through the vertical plate of the palatine bone to the mucosa of the inferior turbinated bone.

The **posterior accessory palatine** nerve descends through the canal of that name, and supplies the soft palate and the posterior pillar of the fauces. The **lateral accessory** nerve, still smaller, escapes below from its canal, and is distributed to the vicinity of the tonsil.

III. **Orbital branches** are two very fine threads which enter the orbit through the inner and hinder extremity of the sphenomaxillary fissure. Passing forwards on the inner wall of the orbit, they pierce the ethmoid either at the posterior ethmoidal hole or by special openings, and are distributed to the palato-ethmoidal and sphenomaxillary cells, and to the sphenoidal sinus.

534. THE INFERIOR MAXILLARY NERVE (p. 597) is the largest branch of the Gasserian ganglion, and carries with it all the motor portion of the fifth nerve, which, in the cranial stage, underlies the sensory, and can be easily separated from it. As it passes outwards and downwards through the foramen ovale, the motor and sensory fibres can now be seen becoming more or less intermixed in a plexiform manner (plexus of Santorini), and the two sets of nerves arising therefrom consequently present some degree of mixture.

535. THE EYE.—The structure of the eyeball can only be made out when the part is quite fresh, and, as many of the points of structure are not widely dissimilar from those of the eye of the ox or sheep, the student should

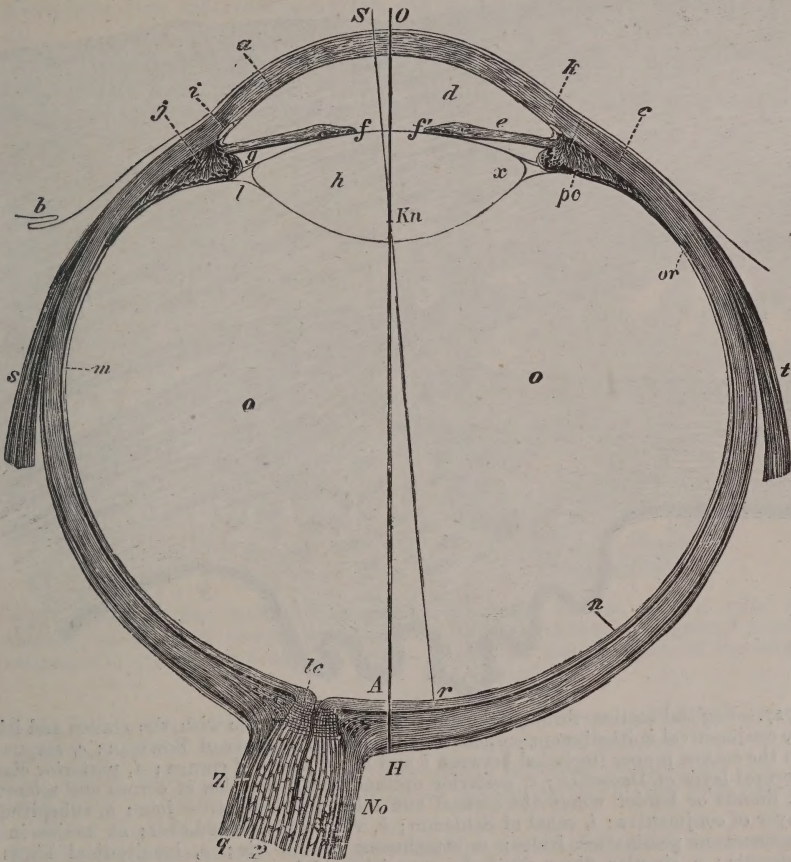


Fig. 726.—Sagittal vertical section through the right eyeball—*a*, cornea; *b*, conjunctiva; *c*, sclerotic; *d*, anterior chamber containing aqueous humour; *e*, iris; *f*, pupil; *g*, posterior chamber; *h*, Petit's canal; *j*, ciliary muscle; *k*, junction of sclerotic and cornea; *l*, canal of Schlemm; *m*, choroid; *n*, retina; *O*, vitreous humour; *No*, optic nerve; *q*, nerve sheath; *p*, nerve fibres; *lc*, lamina cribrosa; *O*, *A*, optical axis; *S*, *r*, visual axis; *r*, position of fovea centralis.

procure several of these first and examine them, subsequently making his knowledge definite by examining the fresh human eye.

Dissection is best carried on by having the eye fastened to a cork plate sunk by leads in a basin filled with normal salt solution.

The **human eyeball** is not quite spherical. The hinder five-sixths form a segment of a spheroid with a radius of 12.05 mm., but a shallow circular sulcus, not far from the anterior pole, isolates an anterior bulging area which is a segment of a smaller sphere with a radius of 7.7 mm. This latter corresponds to the transparent cornea.

There are individual variations in the size of the eyeball; usually the inner half of the ball is less than the outer. For descriptive purposes the extremities of the sagittal axis are spoken of as the poles of the eye, while the circle which divides the eye coronally into fore and hind halves is called the equator oculi.

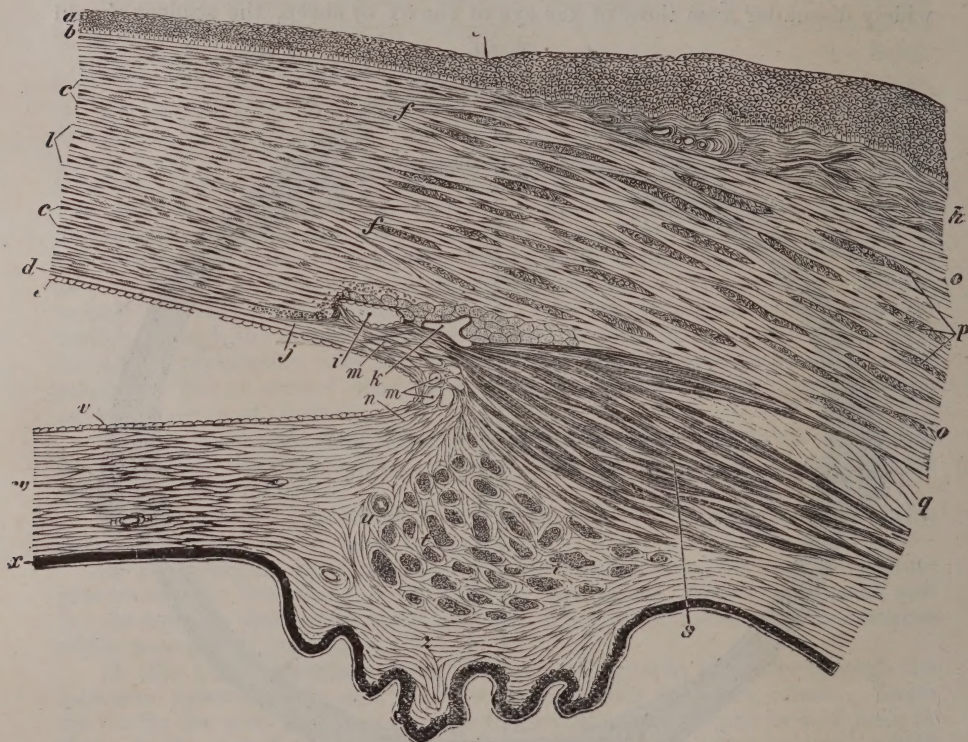


Fig. 727.—Sagittal section through the junction of the sclerotic with the cornea and iris—*a*, conjunctival epithelium or cornea; *b*, anterior elastic layer of Bowman; *c*, corpuscles in the cornea proper (included between *b* and *d*); *l*, layers of cornea; *d*, posterior elastic corneal layer of Descemet; *e*, posterior epithelium; *f*, junction of cornea and sclerotic; *g*, limbus or border where the corneal and sclerotic conjunctivae join; *h*, subepithelial layer of conjunctiva; *i*, canal of Schlemm; *k*, venous plexus of Leber; *m*, meshes in the ligamentum pectinatum iridis; *n*, attachment of the iris; *o*, longitudinal fibres of sclerotic; *p*, circular fibres divided; *q*, perichoroidal space; *s*, radiating fibres of the ciliary muscle; *t*, circular fibres of the ciliary muscle cut through; *u*, lumen of cut ciliary artery; *v*, epithelial layer of iris; *w*, iris; *x*, pigmentary layer; *z*, a ciliary process.

The sagittal axes are distinguished into external and internal, the latter being the distance from the back of the cornea to the front of the retina, while the former is that from the front of the cornea to the back of the sclerotic. The external axis averages 24.27 mm., the inner 21.74 mm. The coronal axis averages 24.25, and the vertical 23.65. The body of the eye is, therefore, ellipsoidal. The optic nerve enters the eyeball about 3 mm. inward from the axis. The eyeball averages 7.2 grammes in weight, and is a little over 6 cm. in volume, with a specific gravity of 1.025.

The eye at birth has a sagittal axis of 17.5, and is nearly globular; at the end of the second year it has grown to 19.5 mm., and at puberty to 21. It rapidly assumes its adult size after puberty. The female eye is usually about 23.9 in sagittal diameter, and is a little less vertically flattened than the male. The two eyes are rarely symmetrical in position and size, but there is not much range of variety in the size of adult eyes. Apparently large eyes differ from those which seem small rather in prominence than in actual size.

The eyeball consists of three composite layers concentrically disposed, an outer or fibrous, a middle or vascular, and an inner or nervous. Within these are three contained transparent media, the vitreous body (fig. 726, *O*, *O*) behind, the crystalline lens intermediately (*ib.*, *h*), and the aqueous humour in front (*ib.*, *d*).

The fibrous coat consists of two parts, the posterior $\frac{5}{8}$ th or **sclerotic** (*ib.*, *j*) is white, opaque, and receives the insertion of the recti muscles (*s*, *i*). It is thickest around the optic nerve (1.1 mm.), but becomes thin as it is continued

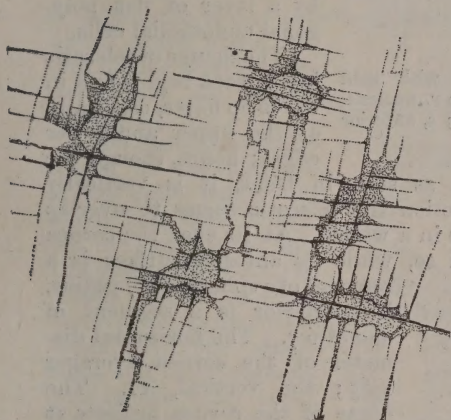


Fig. 728.—Cornea of frog stained with gold chloride, showing the corneal corpuscles stained, also a few nerve fibres.



Fig. 729.—Cornea treated with silver nitrate, showing the ground substance stained and the spaces of the cells left unstained.

forwards, being 0.3 under the recti; it becomes, however, again thickened at the insertion of the recti tendons (0.6). It consists of a felted web of white fibrous tissue obscurely laminated, the fibres crossing each other at right angles; some of these sagittal bundles are continuations of the recti tendons; some, of the tendons of the obliques.

Elastic fibres are mixed sparingly with the superficial, much more with the deep layers of fibres in the sclerotic.

The sclerotic has few vessels, no true lymphatic vessels, and a few fine nerve filaments from the ciliaries.

Posteriorly the sclerotic is pierced by a funnel-shaped opening for the optic nerve, and by small holes for the ciliary arteries and nerves.

Anteriorly the fibres of the sclerotic change in structure when they reach the boundary line (*i*), and are here traversed by a circular canal presenting diverticula and receiving vessels containing venous blood, the canal of Schlemm.

The **cornea** is transparent and distinctly laminated, each lamella consisting of interlacing and decussating connective bundles united by a firm ground substance. Between these lamellæ are clear-edged stellate spaces containing

branched connective cells, whose processes communicate with those of other cells, forming thus a regular network. The lamellæ become more homogeneous towards the surface where it is overlaid by a structureless basement membrane, the **anterior elastic lamina** of Bowman, invested by the 6-8 layers of epithelial cells of the conjunctival epithelium, whose proper basement has here

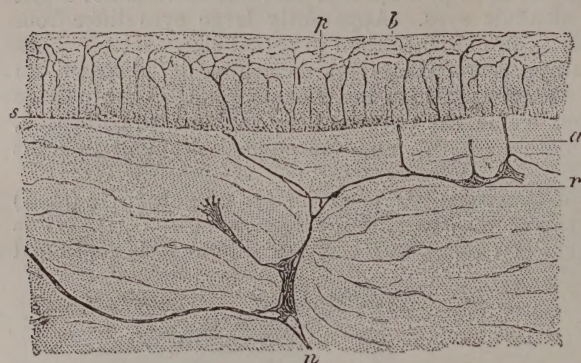


Fig. 730.—Vertical section of cornea stained with gold chloride—*n*, nerve; *a*, its perforating branch; *r*, nucleus; *p*, *b*, inter-epithelial endings of nerve fibrils; *s*, anterior elastic lamina.

corneal margin appears nearly circular, as seen in front, it is vertically elliptical, as seen from within; and in section the sclerotic seems to overlap the cornea as the bezel overlaps the glass in a watch. At its edge the cornea is 1.12 mm. thick, centrally it is .9; and so,

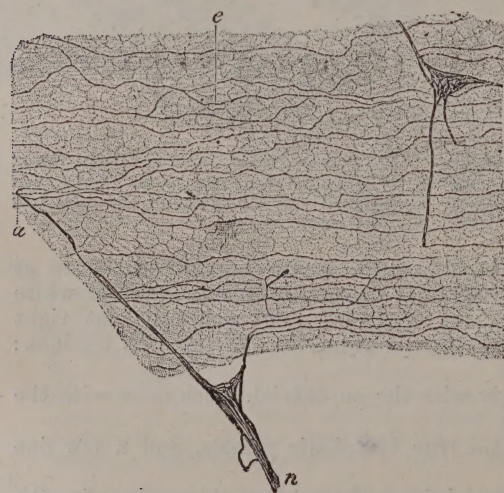


Fig. 731.—Nerve plexus in cornea stained by gold chloride—*n*, nerve; *a*, its fibrils.

except in the middle. These disappear in the adult, except a few peripheral loops, which remain joined to the vessels of the conjunctiva. About forty-five medullated nerve trunks enter the circumference of the conjunctiva, and form in it a non-medullated nerve plexus, from which filaments pass to end

vanished. The deepest of these layers is columnar; the intermediate, polyhedral; the superficial, flattened. The deep layer of the laminated cornea is in contact with a clear transparent lamina, the **membrane of Descemet**, thinner centrally than marginally (6μ – 10μ), which is lined within by a layer of flat polygonal endothelial cells.

The change of sclerotic into cornea begins first in the deep fibres, especially at the upper and lower edges; hence, though the sclerotic seems to overlap the cornea as the bezel overlaps the glass in a watch. At its edge the cornea is a segment of a sphere of 7.7 radius, its posterior is a segment of one of 6.7. The horizontal diameter of the cornea averages 11.5; the vertical, 11. The dome of the cornea projects at the anterior pole 2.6 mm. from the plane of the corneal border.

The superficial corneal lamellæ contain small cells and a few fine interlacing filaments. The deeper layers are quite independent, and the whole cornea is traversed by interfascicular and interlamellar lymph spaces.

The membrane of Descemet is cuticular and structureless, about .008 thick. The refractive index of the cornea is 1.3825.

The foetal cornea is traversed by centripetal looped vessels,

in the epithelial cells. In old age a fatty circle round the corneal border forms the *arcus senilis*.

Divide the sclerotic all round with a sharp-pointed pair of scissors a little in front of the insertion of the recti, and also a little in front of the entrance of the optic nerve; by slitting the ring thus isolated it can be removed, showing the second or vascular layer, with which the pigmentary layer, originally a part of the nervous lamella, has become incorporated in the adult. These, taken together, make up the **choroid coat** in the posterior sphere of the eye. The large lymph space which intervenes between the sclerotic and choroid is traversed by a loose meshwork of fine connective fibres, which collectively are called the **suprachoroid membrane**, in which stellate pigment cells are scattered.

The continuation of the choroid forwards is separated from the back of the cornea by a space full of fluid, the **anterior chamber**, and is called the **iris**. It is centrally perforated by a hole, the **pupil**. The part of the vascular membrane joining together the iris and the choroid is thickened and called the **ciliary body**.

The choroid consists of three layers. The outermost contains large plexuses of veins; the second (*chorio-capillaris*) contains an abundant network of capillaries, under which the thin lamina vitrea separates it from the pigmentary layer.

The choroid is interrupted at the entrance of the optic nerve. In colour it is dark brown, and in thickness .08 mm. The tissue which ties the vessels together is a soft lamellated connective tissue with fine elastic fibres and many pigment cells in the outer layer. The interstitial tissue of the chorio-capillaris is homogeneous.

The arteries entering the choroid are—(1) anterior ciliaries, derived from the muscular arteries entering anteriorly through the sclerotic; (2) the long ciliaries, entering not far from the optic nerve; and (3) the short posterior ciliaries, entering around the optic nerve. These pass into the *chorio-capillaris*, there forming the close-meshed capillary plexus. The branches of the third set supply the most of the choroid; those of the second chiefly run forwards and form arterial loops in the ciliary body; those of the first set uniting with those in the orbicular region of the ciliary body pass forwards into the iris, forming around its attached border a *circulus arteriosus iridis major*, from which radial branches form a long-meshed plexus in the iris, uniting around the pupil in a *circulus arteriosus minor*. The veins begin in obscure stellate plexuses, which unite and form a large vorticosæ series, the *venæ vorticosæ* in the outer layer surrounded by large perivascular canals. These vortices of veins anastomose with each other, and from these escape anterior and posterior choroid veins, which are united with the radicles of the ophthalmic vein.

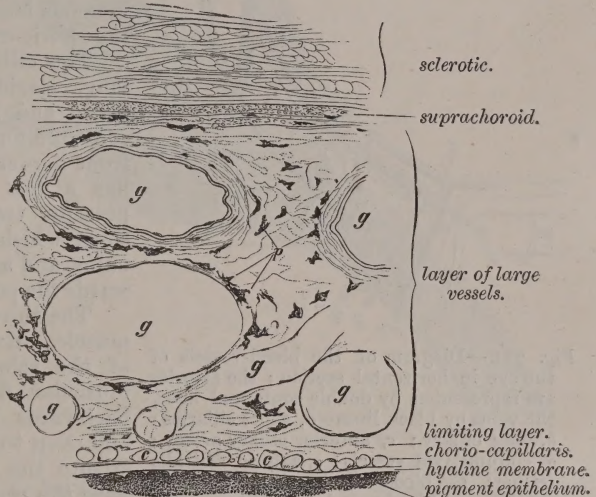


Fig. 732.—Vertical section of choroid—*g*, large vessels usually veins cut through; *p*, pigment cells; *c*, capillaries cut.

To see the ciliary body, cut through the sclerotic by two meridional incisions forwards towards the corneal edge, and reflect it forwards. Cut also a flap of choroid and throw it forwards. Seen from within (fig. 735) the choroid of this region presents three zones from behind forwards; in the first it is radially folded anteriorly (orbiculus ciliaris). This zone begins at a serrated line (ora serrata).

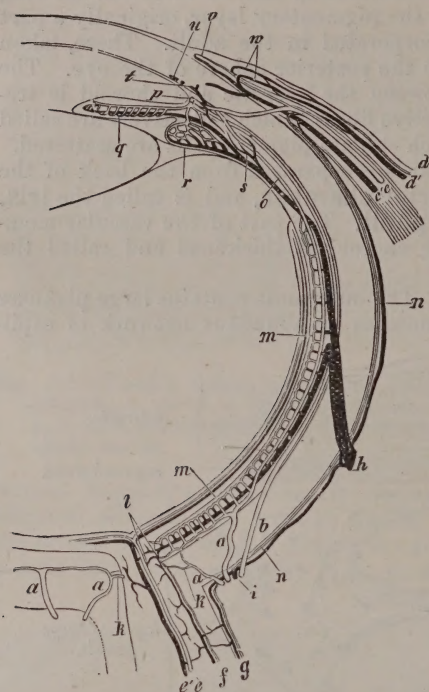


Fig. 733.—Diagram of the blood-vessels of the eye in horizontal section; the arteries are represented by double contoured lines, the veins by black lines—*a*, short ciliaries; *b*, long ciliary; *c*, anterior ciliary artery; *d*, conjunctival vessels; *e*, arteria centralis retinae; *f*, blood-vessels of inner optic sheath; *g*, blood-vessels of outer optic sheath; *h*, vorticosae vein; *i*, posterior short ciliary vein; *k*, branch of post. short ciliary artery to optic nerve; *l*, anastomosis of choroidal and optic branches; *m*, chorio-capillaris; *n*, episcleral branches; *o*, recurrent choroid artery; *p*, circular artery of iris; *r*, ciliary process; *s*, vorticosae vein; *t*, branch of anterior ciliary vein to ciliary muscle; *u*, circular vein; *v*, marginal loops of corneal nerves; *w*, anterior conjunctival vessels.

These folds are very numerous, and as they are traced forwards they unite into about seventy strong processes, forming the second zone of the ciliary processes, whose prominent free borders project anteriorly towards the crystalline lens, around which they form a prominent ring, the ciliary body proper. Some of the folds of the orbiculus are continued between the ciliary processes. In all these folds of the orbiculus the vessels are meridionally disposed, but they become plexiform in the ciliary processes, into which the vitreous lamella is continued, although the chorio-capillaris is not.

The ciliary processes are 2.5 mm. long, meridionally each about 0.12 broad and nearly 1 mm. high. They converge forwards and their prominent front border surrounds the iris. Each has a *root* and a *ridge*; the latter presents two slopes—the long rising slope, which stretches back to the orbiculus, and a short anterior, directed towards the posterior chamber of the eye.

The third zone is that of the ciliary muscle. Externally from the junction of the sclerotic and cornea smooth muscular fibres arise, which stream backwards into the ciliary processes, and even to the orbiculus. These constitute the *radial ciliary muscle* (perhaps the representative of Crampton's muscle), which consists of an outer meridional stratum and an underlying reticular layer (Brücke's muscle). Beneath these, at the base of the ciliary processes, are *circular fibres* (Müller's muscle), which in front form a thick zone, but under the radial these become thin as they extend backwards, even to the orbiculus.

A nerve plexus, with small knots of ganglion cells, overlies these ciliary muscles, sending branches thereto and along the vessels, on which are also small clusters of ganglion cells.

The **iris** is the circular curtain pierced medially by a round hole, the **pupil**, which hangs freely in front of the ciliary processes and in front of the crystalline lens. It is separated from the back of the cornea by the aqueous humour. It is shown by carefully cutting away the cornea with a sharp-

pointed pair of scissors. On doing this the *aqueous humour* escapes, a watery fluid, of which there is about 0.25 grammes, chiefly contained between the iris and cornea in the anterior chamber. It contains traces of albumen and glycogen.

Posteriorly between the iris and the lens there is a small marginal space, the posterior chamber, but medially the iris rests on the front of the lens.

The iris has an attached or ciliary edge and a free or pupillary. It has a hinder radially furrowed surface, the uvea, which is dark brown, and an anterior, visible through the cornea, and generally uneven, except for a small smooth zone around the pupil, into which the radial folds which mark the uvea are continuous round the pupillary edge. These folds are of two kinds—structural folds, which are permanent, and folds due to contraction, which vary. The apparent colour of the iris, brown or blue, which gives the “colour”

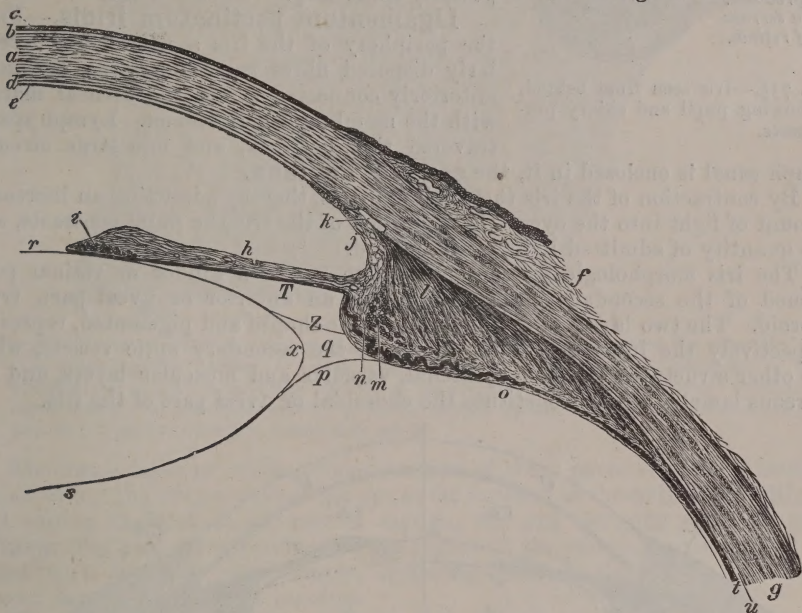


Fig. 734.—Anterior quadrant of a horizontal section of the eyeball through the cornea and border of the lens—*a*, cornea proper; *b*, anterior elastic lamina; *c*, conjunctival layer; *d*, posterior elastic layer; *e*, endothelium; *f*, sclerotic conjunctiva; *g*, sclerotic; *h*, iris; *i*, sphincter iridis; *j*, ligamentum pectinatum iridis; *k*, canal of Schlemm; *l*, longitudinal fibres of ciliary muscle; *m*, circular fibres of ciliary muscle; *n*, ciliary process; *o*, ciliary part of retina; *p*, posterior layer of hyaloid membrane; *q*, canal of Petit; *r*, anterior layer of capsule of lens; *s*, posterior layer of ditto; *t*, choroid; *u*, perichoroidal space; *T*, pigment epithelium of iris; *x*, margin of lens; *Z*, zonula of Zinn.

to the eye, depends on the pigment of the uvea, which is contained in simple or branched pigment cells, and which looks blue or grey according as its aspect is modified by the interference effect of the tissues of the iris. The pigment usually extends into the pupillary zone defining its border.

The iris diminishes in thickness to the pupillary edge, but not uniformly. In structure it is only a special case of the structure of the ciliary body, rich in blood-vessels and girt with a sphincter muscle.

The pigment cells are grouped in irregular masses, and shine through. In the fetus they were covered by a continuous layer of flat cells, but these break up as the eye grows, and only appear in patches, except around the ciliary

edge. On the hinder surface of the connective stroma of the iris there is a posterior boundary layer of radially fibrillated membrane, which, however, is non-muscular, and is only covered by a bilaminar endothelium, whose anterior layer is of spindle cells, its posterior of cubical.

The sphincter pupillæ consist of smooth circular muscle bundles, making a zone .6 mm. broad, thickened at its outer border and supplied through the ciliary nerves from the ciliary ganglion with fibres from the third nerve. A very thin layer of radial fibre cells lies in front of the boundary layer in some animals, but are not demonstrable in man. They are inserted into the sphincter and form the dilator pupillæ. These are supplied by sympathetic filaments, possibly inhibitory.

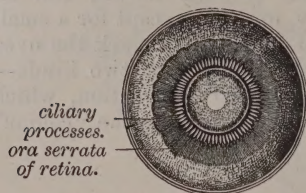


Fig. 735.—Iris seen from behind, showing pupil and ciliary processes.

Ligamentum pectinatum iridis.—From the periphery of the iris a network of irregularly disposed fibres passes forwards, becoming anteriorly connected round the corneal margin with the membrane of Descemet. Lymph spaces traverse this network, and one large circular

lymph canal is enclosed in it, the **canal of Fontana**.

By contraction of the iris the pupil expands, thereby admitting an increased amount of light into the eye. By expansion of the iris the pupil contracts, and the quantity of admitted light is diminished.

The iris morphologically consists of two parts—a hinder or retinal part, formed of the secondary optic vesicle, and an anterior or uveal part, truly choroid. The two layers of epithelium, spindle-shaped and pigmented, represent respectively the inner and outer layers of the secondary optic vesicle, while the other structures, anterior epithelial, vascular and muscular layers, and the vitreous lamella behind constitute the choroidal or uveal part of the iris.

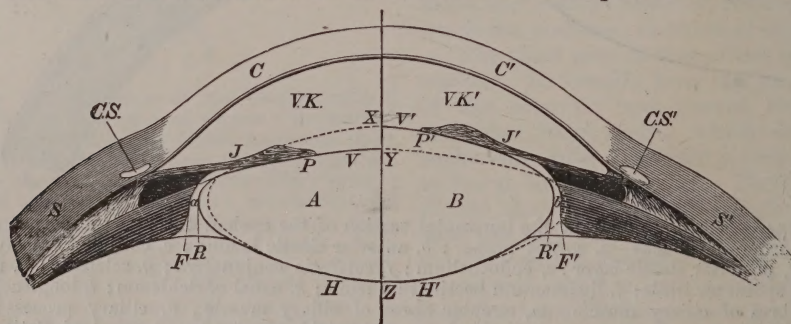


Fig. 736.—Diagram of section through anterior chamber and lens, showing the changes which take place during the accommodation of the eye to vision at different distances. The right side is accommodated for a near object, the left side is in the normal, neutral position—A B, lens; C, cornea; S, sclerotic; C S, Schlemm's canal; V K, anterior chamber; J, iris; P, border of pupil; V, anterior surface of lens; H, posterior surface of lens; R, margin of lens; F, margin of the ciliary processes; Z X, thickness of lens when accommodated for a near object; Z Y, thickness in the passive condition of eyeball.

The retina is best shown by dividing the choroid around the equator and reflecting it forwards and backwards. It is formed by the walls of the secondary optic vesicle, and consists, therefore, of an inner and an outer layer. The outer is modified into a layer of pigment cells, the **tapetum**, and is so closely connected to the choroid as to appear like an inner layer of that membrane. The tapetum consists of a single layer of hexagonal, densely pigmented

cells, flattened towards the choroid, irregular towards the retina. It is continuous on the back of the iris as far as the pupillary border, but here it is primitively double.

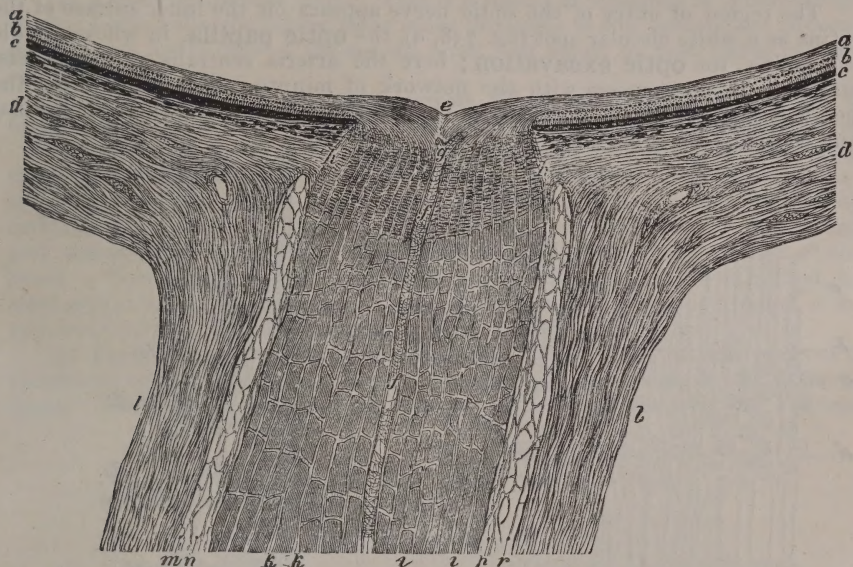


Fig. 737.—Horizontal section through the optic nerve at its passage through the sclerotic, $\times 25$ —*a*, inner layer of retina; *b*, outer layer of retina; *c*, choroid; *d*, sclerotic; *e*, optic excavation; *f*, arteria centralis retinae; *g*, its division; *h*, lamina cribrosa; *l*, sheath of dura mater; *m*, subdural space; *n*, subarachnoid space; *r*, arachnoid sheath; *p*, pial sheath; *i*, nerve fibres; *k*, connective septa.

The inner layer or retina proper consists of three parts—(1) the functional retina lining the deeper part of the eye as far forward as the **orbiculus ciliaris** and ending in front in an uneven margin, the **ora serrata**; (2) the **pars ciliaris** (fig. 734) corresponding to the region of the ciliary processes; (3) the iridal part, which is rudimentary, appearing only as the second layer of the iridal tapetum.

The **pars ciliaris** consists of a row of columnar cells which diminish in height from about 50μ to 14μ from behind forwards, and with irregular borders which interlock with each other. These are generalised descendants of the cells of the optic vesicle.

The true retina consists of three sets of elements:—(1) The nervous mechanism an expansion of the brain; (2) the neuro-epithelial mechanism which directly takes cognisance of the vibrations of light; and (3) a support apparatus by which these are sustained. It varies from $\cdot 45$ to $\cdot 14$ mm. in thickness, is transparent during life, but becomes turbid and opalescent after death.

The optic nerve becomes continuous with the retina (fig. 737) by piercing the sclerotic, which at this spot is broken up into a cribriform plate to allow of the entry of the nerve fibres. The meshes of this **lamina cribrosa** are in eight to ten strata at the area of entry of the nerve. The diameter of the perforated lamina is $1\cdot 7$ mm., that of the nerve 3 mm., the difference being due to the condensation of the

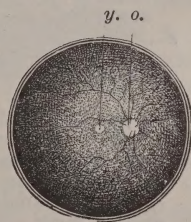


Fig. 738.—View of hinder half of eyeball seen from the front, showing the yellow spot, *y*, and the optic papilla, *o*.

nerve from the loss of sheath and endo-neurium at its entry. The nerve fibres in like manner pierce the choroid which forms the inner stratum of the lamina cribrosa.

The region of entry of the optic nerve appears on the inner surface of the retina as a white circular spot (fig. 738, *o*), the **optic papilla**, in whose middle is a hollow, the **optic excavation**; here the arteria centralis retinae enters, and here it anastomoses with the network of minute vessels which cross the nerve accompanying the trabeculae of the cribriform plate: elsewhere the retinal and choroid vessels have few, if any, anastomoses.

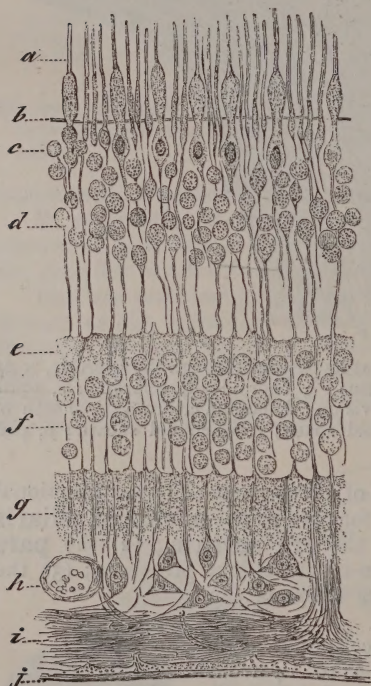


Fig. 739.—Vertical section of human retina—*a*, bacillary layer of rods and cones; *b*, external limiting layer; *c*, external nuclear layer; *d*, granule; *e*, external granular layer; *f*, internal nuclear layer; *g*, internal granular layer; *h*, blood-vessels and nerve-cells; *i*, nerve-fibres; *j*, internal limiting layer.

The nerve elements of the retina (fig. 739) are on its internal surface, and consist of (1) fibres of the optic nerve; these are pale, delicate fibres which form the papilla and constitute a thick layer around this, thinning to the periphery.

(2) Internal to the nerve fibres is a layer of ganglion cells, large, multipolar, and, for the most part, in one layer. They are embedded in an abundant intercellular tissue, and become a little interrupted towards the ora serrata, where they gradually fade out.

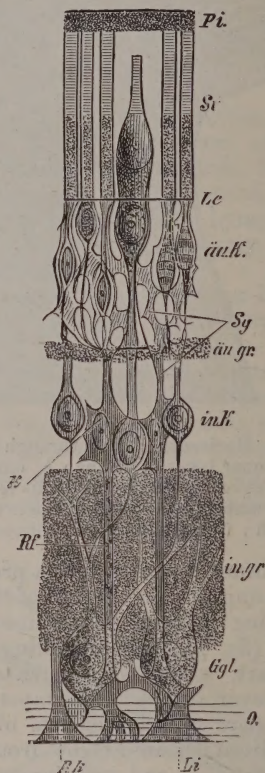


Fig. 740.—Scheme of the layers of the retina—*Pi*, hexagonal pigment cells of tapetum layer; *St*, rods and cones; *Le*, external limiting membrane; *auk*, outer nuclear layer; *Sg*, spaces for the nerve elements; *au gr*, external granular layer; *inK*, inner nuclear layer; *in.gr*, internal granular layer; *K*, nuclei; *Rk*, *Rf*, fibres of Müller; *O*, fibres of optic nerve; *Li*, internal limiting layer.

(3) Outside this layer is the inner reticular layer made up of the interlacement of the protoplasmic processes of the ganglion cells in a finely granular matrix. This neuro-spongium unites the last to—

(4) The inner nuclear layer. This is a lamina of stratified or spindle-shaped bipolar nerve cells, united by their inner processes to the protoplasm processes of the large nerve cells of the second layer, and which by their outer processes are continuous into—

(5) The outer reticular layer, a narrow, subepithelial lamina resembling the third, and containing a few branched cells which may belong to the support tissues.

The neuro-epithelial elements are—(6) The basal cells whose outward extensions are the rods and cones. These cells are arranged in various strata so as to fit together, and each is in the course of a fibre continued out from the outer reticular layer. These fibres are of two kinds—rod-fibres, fine, usually varicose and resembling nerve fibres; and cone-fibres, which are thicker, swollen at their bases. The nuclei on the rod-fibres are elliptical, and are stratified into alternate clear and dark laminae, hence they seem transversely striped, a dark spot surrounded by a clear zone appearing at each pole.

(7) From the outer surface of the last there project the rods and cones of the outermost or bacillary layer, each of these consist of two elements, outer and inner. The inner segments of the rods are cylindrical, $60\ \mu$ long and $2\ \mu$ broad.

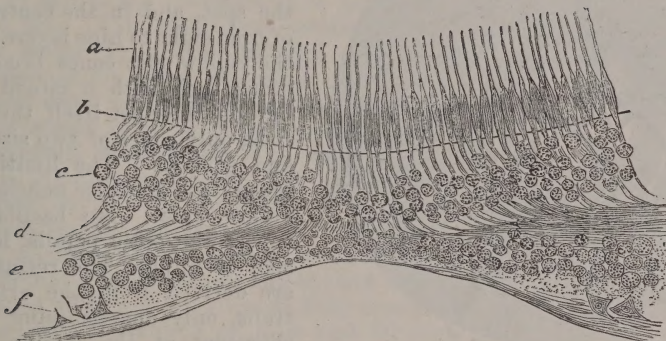


Fig. 741.—Section of retina at the fovea centralis—*a*, cones; *b*, outer limiting layer; *c*, external granular layer; *d*, fibres; *e*, nuclear layer; *f*, nerve cells; *g*, inner limiting layer.

The outer are cylindrical, homogeneous, and regularly disposed. In these outer segments of the rods is contained a peculiar pigment, acted on by light and appearing purple in a retina kept in darkness.

The inner joints of the cones are conical, set on the outer side of the nucleated cone-fibres of the sixth layer. The outer joints are short, slender, and pointed cones in general, are more sparsely diffused than rods, except in one region; but there are about three millions and a half of them in the retina, together with about fifty millions of rods.

The supporting tissues consist of radial Müllerian fibres of neuro-keratin, these are conically expanded internally around the bases of the cones, uniting in and internal to the first layer, so as to form by the contiguity of their margins an internal limiting layer, not a continuous membrane. The fibres are united, external to these cones in a dense network which supports the protoplasm cell-processes in the inner reticular layer, and which makes the neuro-spongium of this lamella. Masses of this material project into the nuclear layer, making the spongioblasts between the ganglion cells; and the Müllerian fibres in this layer are thick, irregular and nucleated, moulded to the outside of the ganglion

cells. Beyond this the fibres again break up into a network, the basis of the outer reticular layer, beyond which the continuation of the fibres are similarly irregular to support the basal cells of the rods and cones, and by their unions beneath the inner segments of these they form the external limiting membrane, which is consequently a network pierced by these processes. The outer ends of the rods and cones are sunk into pits in the inner surfaces of the pigment cells of the tapetum, whose fine, semifluid protoplasm processes project into the intervals between these.

External to the papilla is an oval *yellow spot*, whose diameter is 2 mm., and whose centre is 4 mm. from the middle of the papilla. The centre of the yellow spot is depressed into a fovea centralis 0.3 mm. in diameter, the thinnest part of the functional retina and the most transparent. This fovea is .78 mm. below the horizon of the middle of the pupil and approximately at the hinder pole of the sagittal axis of the eye. From its transparency its yellow colour is not perceptible during life. This macula lutea is in the line of the primitive

fissure of the secondary optic vesicle, and consequently the fibres of the optic nerve arch round it, few passing beneath it. The ganglion cell layer becomes bilaminar around the spot, and in the centre consist of from eight to nine layers. Around the yellow spot cones become numerous, each with a circlet of rods, but on the spot itself there are no rods, only cones of two sizes, larger and smaller. The limiting membranes are likewise deficient at the yellow spot. No bacillary layer covers the optic papilla, hence this spot is blind. The retinal vessels are derived from the arteria centralis, only anastomosing with the choroidal at the lamina cribrosa.

No vessels extend external to the outer reticular layer, nor into the centre of the fovea centralis. The branches of the arteria centralis are arteria nasalis, superior and inferior; arteria macularis, superior

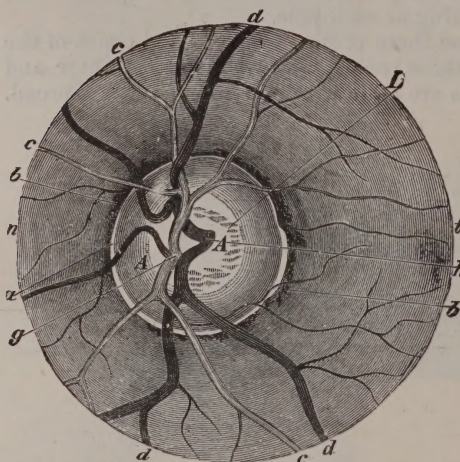


Fig. 742.—Fundus of eye as seen with the ophthalmoscope—*a*, ring of connective tissue; *b*, choroidal ring; *c*, arteries; *d*, veins; *g*, branches of the central artery; *h*, branches of the central vein; *L*, lamina cribrosa; *n*, nasal or inner side; *t*, temporal or outer side.

and inferior; arteria temporalis, superior and inferior; and arteria mediana, superior and inferior. Their distributions are shown in the figure; with each artery there is a vein.

The retina is extended over the **vitreous body**, a spheroidal mass of gelatinous, connective tissue enclosed in a delicate *hyaloid* membrane, which retains traces of the original form elements, but these have quite disappeared from the central mass. The only traces of organisation usually remaining in the adult are a few lamellæ which dip into the mass from the hyaloid membrane. In the fœtus the branches of the arteria centralis entered it, but in the course of its specialisation these divide into two groups, a peripheral, which become laterally displaced and finally are distributed to and lie on the surface of the retina; and a central arteria hyaloidea, which passes forwards to the membrana capsularis at the back of the crystalline lens. This also disappears before birth, its canal, the canal of Cloquet, alone remaining.

The vitreous humour measures 22 mm. along its longest (diagonal) diameter,

and 10 along its antero-posterior axis, which form the hinder half of the optic axis; it is 6.6 grms. in weight, and has a refractive index of 1.3344. Anteriorly, it is depressed into a concavity (**fossa patellaris**) wherein lies the lens, meridionally around this it is radially folded and striated to mould itself upon the ciliary processes, the coronet of rays forming the **zonula ciliaris**. The hyaloid membrane of the zonula is continuous with the front border of the capsule of the crystalline lens, and this part is rather firm, presenting a series of radiating fibres called the suspensory ligament of the lens. The interspaces between these fibres during life are filled with a semifluid forward extension of the vitreous humour, and when emptied they constitute around the margin of the lens a circular space, said to be irregularly triangular in section, the **canal of Petit**. Its calibre varies, when it is distended, with the shape of the overlying zonula. Where that rises into a ridge, it is widest; where it is depressed by the ciliary processes, it is narrowed to a mere slit. This moniliform condition can be shown better by gentle inflation with a blowpipe than by coloured fluid injection, as the latter can escape through fine gaps in the anterior wall, whereby the canal communicates with the posterior chamber. Petit's canal, however, is largely an artificial product.

The **hyaloid membrane** is in contact with the internal limiting membrane, but belongs not to the retina but to the connective contents of the secondary vesicle: close beneath it are scattered leucocytes, rounded, often amœboid or vacuolated; but these do not form a distinct sub-hyaloid layer. The contained matter of the vitreous body consists of 97.8 per cent. of water, 2 of salts and soluble animal matter, and 0.2 of organised material. This is not arranged in any definite network. By reagents an appearance of meridional cleavage or of concentric lamination can be produced, but much of these seems artificial. The only true structural appearances to be found are the central canal with its funnel-like dilatation (area Martegiana) opposite the optic papilla. Around the ora serrata very fine connective fibres pass from the ciliary processes to form the zonula. It is an extreme case of dropsical mucous tissue.

The zonula is about 6 mm. broad, and intervenes between the ora serrata and the edge of the lens. It consists of alternate ridges and hollows, and into each of the latter a receding pouch of the posterior chamber is continued; but the sides of these grooves are inseparably attached to the sides of the hinder long slopes of the ciliary processes except at the points of the latter which are free.

The crystalline lens is the most important refractive medium in the eye, and lies directly behind the iris; it is doubly convex, but flatter in front, and lies on the fossa patellaris of the vitreous body. The two surfaces meet in a circular

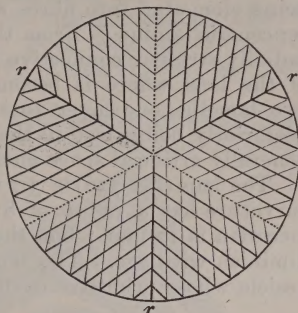


Fig. 743.—Diagram of course of fibres of crystalline lens, diverging from the anterior radial lines (*r*) to the posterior (dotted) radial lines.

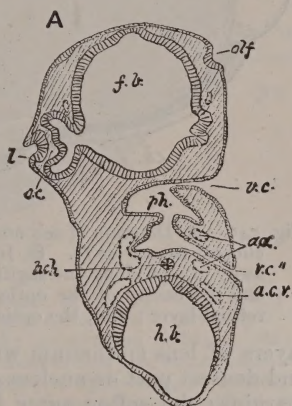


Fig. 744.—Section of the head of an embryo fowl of sixty-four hours' incubation—*f. b.*, fore-brain; *h. b.*, hind-brain; *l*, outer optic vesicle; *o. c.*, internal optic vesicle; *v. c.*, visceral clefts; *ph*, pharynx; *olf*, olfactory pit; *nch*, notochord; *a. a.*, aortic arches; *acv*, anterior cardinal vein.

equator (fig. 736). The lens is invested by a clear elastic homogeneous capsule, beneath which the proper substance of the lens consists of modified epithelial cells, those of the front being short and cubical lens-epithelium, those posteriorly being elongated into fibres which are flattened, hexagonal columns arranged in concentric laminae. From the ciliary processes and their intervals the delicate radially striated connective lamellae of the zonula ciliaris passes to the equator of the lens, where it becomes condensed and can artificially be divided into two lamellae, one layer passing in front lost in the front of the capsule, one posteriorly being lost in the wall of the fossa patellaris, and the irregular and generally artificial space enclosed in the cleavage is the canal of Petit.

The lens (fig. 736) is 3.7 mm. in sagittal, 9 in equatorial diameter. Its front curvature has a radius of 8.2 mm., its posterior of 6 mm., and the length of its meridian is 12 mm.; but these curves vary with the diameter of the eye and diminish with age. The lens is the modified epithelium of the external optic vesicle whose primitive cavity is represented by the line of contact of the front

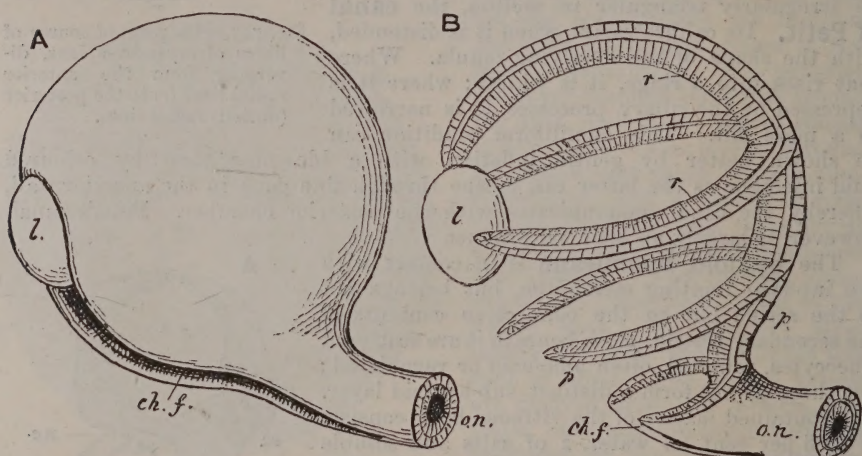


Fig. 745.—A, Diagram of secondary optic cup with the lens (*l*) in the upper portion of the choroid fissure (*ch.f.*). B, Ideal dissection of the optic cup whose substance has been cut away except along one sagittal and several horizontal lines, showing the choroid fissure and the cavity of the optic cup (vitreous chamber); *p*, the pigmentary layer; *r*, the retinal layer; *o.n.*, the optic nerve.

layers of lens epithelium with the hinder or fibrous material. The innermost and densest part or nucleus consists of the oldest fibres which have denticulate margins; the softer outer layers are newer, and their margins are generally plane. Each fibre is obscurely striated, and consists of a firm periphery, swollen at the nuclear area and a softer central substance. Near the equator where the cells are transitional, there is a nuclear zone with rather large cells, which from this backwards become obliquely and finally meridionally placed and lengthen as they extend backwards. The fibres of each layer do not form a continuous parallel series, but are arranged in groups, whose ends are opposed to each other, along certain lines. These lines are arranged in a stellate manner on each surface of the lens. The star in the foetal lens is tri-radial and so arranged that the rays on one surface of the lens correspond to the inter-radial spaces on the other, each fibre (fig. 743, *r*, *r'*) in starting from one ray passes round the equator to end at the ray on the other side, as indicated by a dotted line. As age advances, new planes of division appear, the star becoming six-rayed, and the entire lens grows in volume, its dimensions at 65 being $\frac{1}{10}$ greater than at 25.

The capsule of the lens is a modified cuticular layer; the corona ciliaris is derived from the modified dermis of the outer optic vesicle around the border of the lens. It was originally vascular in the fetus, and its continuation behind the lens formed the foetal **membrana capsularis**, fed by the hyaloid artery. The continuation in front of the lens was the **membrana pupillaris** which was fed by the vessels of the contiguous iris. Both these layers begin to atrophy in the seventh month with the rapid growth of the vitreous body and have disappeared at birth.

The slit-like space between the iris and the lens is the **posterior chamber**; it is wider peripherally where it receives the ciliary processes, but otherwise it is only a nominal space. It communicates through the pupil with the **anterior chamber** containing the aqueous humour.

The curvature of the lens varies during life with the action of the ciliary muscle; when the eye is focussed for near vision the curvatures alter from those given above, as represented in fig. 736. The anterior curvature has then a radius of 6.0 mm., and the back of 5.5. In rest, the anterior surface is the segment of an elliptically curved surface; the posterior, that of a parabola.

Chemically, the lens consists of 65 per cent. of water, 35 per cent. of animal albuminous matter; the refractive index of its surface is 1.4053, and of its denser part 1.4541; it is doubly refracting.

The capsule of the lens is from 11 to 15 μ in thickness in front, from 5 to 7 μ behind, and thinnest at the hinder pole.

In the primitive cavity of the lens there is occasionally a clear drop of albuminous fluid (Liquor Morgagni). The fibres of the lens do not increase in number from their full formation in the fourth-month fetus until after birth, but after this they double in number as well as increase in size.

Development.—The eye is developed from a twofold source—an inner, which is an outgrowing hollow vesicle (the internal optic vesicle) from the hinder part of the anterior cranial vesicle, and an outer, which is a pit from the surface above the maxillary lobe (fig. 744). The latter projecting against the fundus of the former causes it to become invaginated into an **optic cup**, whose mouth consists of a wide portion above and anteriorly, and a narrow slit posteriorly. The stalk of the cup narrows and becomes the optic nerve. The outer pit of invagination closes and forms a closed spheroidal sac of epithelium which sinks into the mouth of the optic cup; its front layer of cells remains short, but the hinder cells become

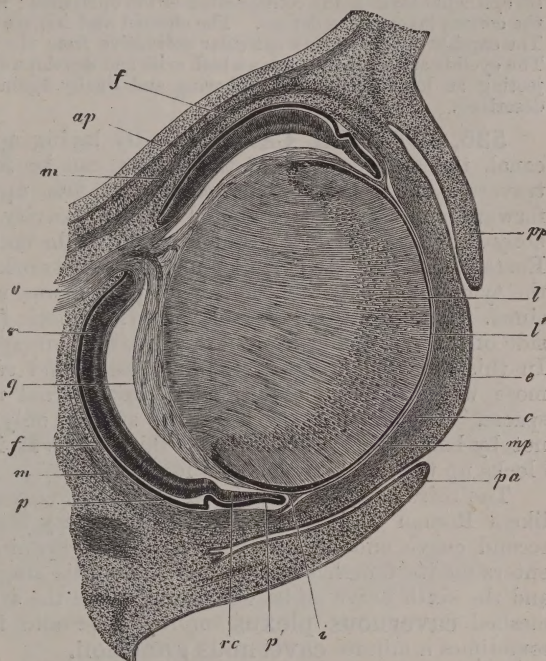


Fig. 746.—Horizontal section of the eye of a rabbit of eighteen days—*ap*, orbito-sphenoid; *c*, cornea; *e*, its epithelium; *f*, choroid; *g*, vitreous body; *i*, iris; *l*, lens; *l'*, epithelium of front of lens; *m*, rectus superior; *mp*, membrana pupillaris; *o*, optic cup; *p*, outer pigmented layer of retina; *p'*, front edge of secondary optic cup; *pa*, upper eyelid; *pp*, lower eyelid; *r*, retina; *rc*, ciliary part of the retina.

elongated and fibrous, so that ultimately the cavity degenerates into a slit and the mass of epithelium forms the crystalline lens. This body (*l*) fills the front part of the mouth of the optic cup, as shown in fig. 745. When the fundus of the optic cup is driven in, it appears to consist of two layers—an anterior, the invaginated fundus layer, which is thick, and becomes the retina, and a posterior, which becomes the pigmentary layer of the choroid, but which is really derived from the optic cup, not from the surrounding connective tissues as are the choroid and sclerotic. The retina is at first only one cell deep, but soon becomes complex in structure. The slit-like depression along the under side of the optic cup is called the choroid fissure, and extends along the optic nerve. It is into the closed remains of this fissure on the nerve that the *arteria centralis retinae* is interjected, and through this fissure on the eyeball, the vitreous humour, a mesoblastic structure has grown inwards. The cornea is formed by the coalescence of the tegumentary structures after the sinking in of the lens; its epithelial layer is the continuation of the epidermis; its deeper tissue is a modification of the corium layer of the dermis. The choroid and iris are likewise mesoblastic interjections. The capsule of the lens is a cuticular derivative from the epidermal cells of the lens itself. The eyelids are secondary folds which arise and develop around the corneal area, at first projecting as loose folds, then adhering and finally again separating, as has been already described.

536. INTERNAL CAROTID.—By laying open with a chisel the carotid canal, the second stage of this artery can be followed (p. 602). The vessel traverses the petrous bone, passing at first upwards, then turning sharply forwards and inwards, separated from the cavity of the tympanum by a thin, bony lamella, lying below and internal to the cochlea, and crossing behind the Eustachian tube. It is surrounded by a network of small veins, derived from the tympanic cavity and the basilar periosteum, which open into the cavernous sinus. The carotid plexus of the sympathetic (p. 610) ascends on the outer side of the vessel, and is often condensed at one spot into a **carotid ganglion**. In this stage the artery gives off *tympanic* and *vidian* branches, which anastomose with their namesakes from the internal maxillary in their respective spaces. The end part of the second stage is only covered above by membrane, not by bone, and passes into the third stage as it lies on the cartilage, which blocks up the anterior lacerated foramen.

The third stage, on the inner wall of the cavernous sinus, is doubly curved like a Roman *o*, its first or hinder concavity being directed downwards. Its second curve ends at the carotico-clinoid opening, beyond which the artery enters on its fourth stage (p. 698). In this stage it has the cavernous sinus and the sixth nerve on its outer side, while the sympathetic fibres form a close-meshed **cavernous plexus** on its lower and inner side. In this there is sometimes a minute **cavernous ganglion**.

The branches in the third stage are *receptacular* to the walls of the cavernous sinus, *pituitary* to the hypophysis, *ganglionic* to the Gasserian ganglion, and *meningeal* to the dura mater, all small branches.

THE ORGAN OF HEARING.

537. THE ORGAN OF HEARING consists of three parts—the external, middle, and internal parts of the ear (fig. 747). The **external ear**, which has been already dissected (p. 523), is the specialised modification of the tegumentary margin of the first post-oral visceral slit. The middle is the modified deep portion of the cavity of that cleft, containing in it the modified remains of portions of the first and second visceral arches. The internal ear or labyrinth is the essential organ of hearing, and should be first examined.

To see it, decalcify a *fresh* temporal bone in dilute acid (p. 32), and remove carefully the bone from around its tubules. This part of the apparatus consists of two parts—(1) the **membranous labyrinth**, on and in which the auditory nerves end, and (2) the **bony labyrinth** or the tubular excavations in the petrous bone, wherein the former is contained.

In the course of dissection the bony labyrinth should be dissected first, but to understand the structure of this organ, it is better to begin the description with the membranous labyrinth, which is the essential part of the organ as well as historically its oldest part.

This membranous labyrinth (fig. 748) consists primarily of two sacs—one elliptical (the **Utriculus**), placed above and behind; the other subglobular (**Sacculus**), internally and in front. These are formed by a duct, from which, near its saccular end, there passes a fine tube, the **ductus endo-lymphaticus**, which passes through the temporal bone towards the sigmoid groove, dilating under the dura mater into a **saccus endo-lymphaticus**, which soon vanishes in course of growth (fig. 752, III, R).

From the upper and outer side of the utricle there pass three **semicircular canals**, placed at right angles to each other; one of these, the highest, is directed in the coronal plane, and is at the same time anterior to the others and vertically placed; a second, the longest, but narrowest, is placed posteriorly

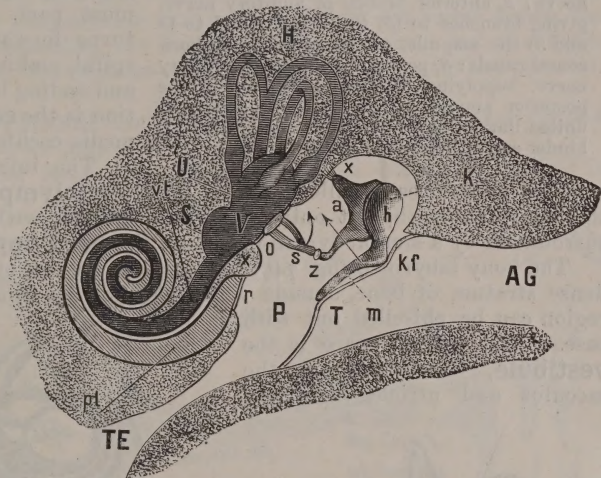


Fig. 747.—Scheme of organ of hearing—AG, outer ear meatus; T, membrana tympani; K, malleus, with its head (h), short process (kf), and handle (m); a, incus; x, its short leg; s, stapes; z, Sylvian ossicle; P, middle ear; o, fenestra ovalis; r, fenestra rotunda; x, beginning of cochlea; pt, scala tympani; vt, scala vestibuli; V, vestibule; S, saccule; U, utricle; H, semicircular canals; TE, Eustachian tube. The long arrow shows the line of traction of the tensor tympani; the short curved arrow that of stapedius.

in the sagittal plane, also vertical and internal to the others; the third, the shortest and widest, is placed horizontally, and is external to the others. These canals are respectively named **superior**, **posterior**, and **external**. These canals join the utricle at each end.

One extremity of each canal is dilated into an **ampulla**. The highest and farthest forward of these ends is the ampullated end of the superior canal, next to this the ampullated end of the external, then the united non-ampullated

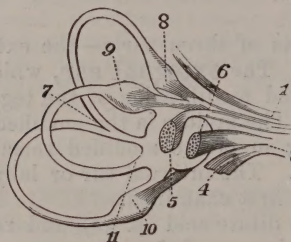


Fig. 748.—Membranous labyrinth—1, facial nerve; 2, anterior branch of auditory nerve, giving branches to (5) the utricle; and to (8 and 9) the ampullæ of the superior and horizontal canals; 3, posterior division of auditory nerve, supplying (6) the saccule; (10) the posterior ampulla; and (4) the cochlea; 7, united limb of upper and posterior canals; 11, hinder end of horizontal canal.

ends of the superior and posterior, which form a common stem before they end in the utricle. Below is the non-ampullated end of the external canal, and lowest of all is the ampullated extremity of the posterior canal.

The saccule is somewhat flattened, and sends off one tubular outgrowth of peculiar form, beginning as a narrow tube, the **canalis reuniens**, from its lowest and hindmost part. This canal suddenly turns forwards, and is coiled in a spiral, making two and a-half whorls and ending blindly. This spiral portion is the **cochlear canal**, or scala media cochleæ (fig. 752, III, Cr).

The interior of all these membranous structures is filled with a fluid, **endolymph**, and they lie within the bony labyrinth, but only partially in contact with its walls, as they are surrounded by a similar lymph-like fluid, the **perilymph**.

The bony labyrinth (fig. 749) consists of three sets of spaces surrounded by a dense stratum of bone, outside which the petrous bone is cancellous, so this region can be chiselled out with ease. The central space is the **vestibule**, which contains the sacculus and utricle (fig. 750),



Fig. 749.—External appearance of bony labyrinth when chiselled out—f, superior semicircular canal; s, posterior canal; h, external canal.



Fig. 750.—Interior of labyrinth of right ear, with the outer wall removed—1, beginning of cochlea; 2, posterior semicircular canal; 3, horizontal canal; 4, superior canal; 5, utricle; 6, saccule; 7, lamina spiralis; 8, ampulla of superior canal; 9, ditto of horizontal; 10, of posterior.

and from which pass three **bony semicircular canals**, holding the membranous canals, and the **cochlea**, holding the spiral cochlear canal.

The perilymph is truly lymph contained in a wide lymph path. There is a lax series of connective bands traversing the fluid, holding the membranous parts in their place, and a large lymph cistern occupies the vestibule on its outer side. The bony walls of these cavities are dense and lined by thin periosteum, so that they can easily be separated from the rest of the temporal bone.

The **vestibule** is elongated, and measures 4 mm. vertically, 5 mm. sagittally, 3.5 mm. coronally. Internally it abuts on the meatus auditorius internus, externally on the tympanic cavity, with which it communicates by the fenestra ovalis; the anterior internal surface joins the cochlea; from the posterior and external surface pass the semicircular canals. The floor and inner wall are depressed into two pits, the **spherical recess** for the saccule, the **elliptical** for the utricle, separated by a vertical *crista vestibuli*, which ends in a pyramid above, sending off two weak processes below, one internal and anterior round the saccule, and a posterior stretching to the ampulla of the posterior semicircular canal. These surround the pit for the recessus cochlearis, into which a caecal pouch of the cochlear duct bulges. The openings into the vestibule are the five mouths of the semicircular canals, the fenestra ovalis, the minute holes of the macula cribrosa, of which the upper set pass to the upper end of crista vestibuli for the utricle and the ampullae of the upper and outer semicircular canals; the middle set enter below the recessus sphericus, transmitting the nerves for the sacculus, and the lower series of holes are below the recessus ellipticus for the nerves for the posterior canal.

The **aqueductus vestibuli** lies below the mouth of the combined portion of the anterior and posterior canals.

The bony semicircular canals are about 1.5 mm. in diameter, elliptical in

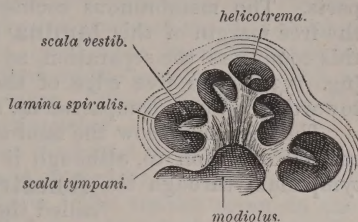


Fig. 751.—Coronal section of bony cochlea.

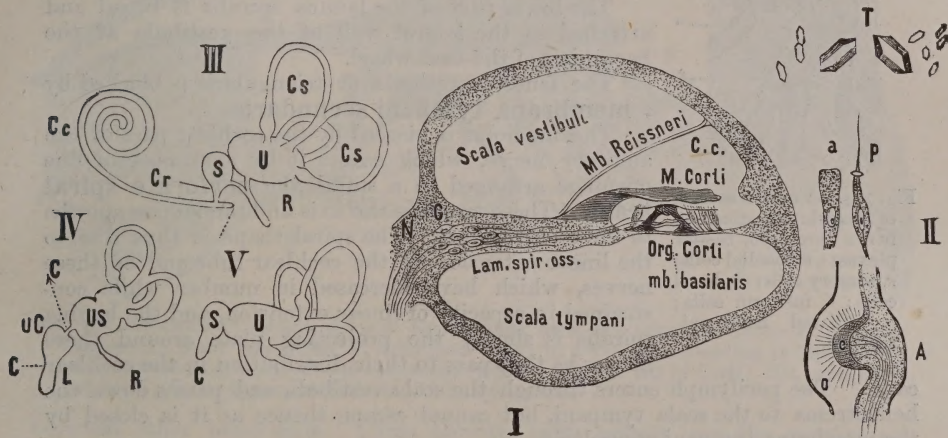


Fig. 752.—III, Scheme of labyrinth; Cs, semicircular canal; U, utricle; S, saccule; R, endolymphatic duct; Cr, canalis reuniens; Cc, cochlear canal; IV, scheme of bird's labyrinth; V, fish's labyrinth.

Fig. 753.—I, Transverse section of one whorl of the cochlea; II—A, ampulla of semicircular canal, with crista acustica; a, p, auditory cells; T, otoliths.

section, and are ampullated, the superior corresponding to the jugum petrosum (p. 223), and its arch to the floccular fossa. These canals show faint secondary flexures, but these are individually variable, and they are not uniform in lumen.

The **bony cochlea**, like the membranous, is a coiled, tapering, spiral tube, with two and a-half whorls (fig. 751), the first beginning below and directed

forwards and inwards. The whorls, as seen from without, are close together, and end forwards and inwards in a dome, the **cupola**; the opposite posterior and external side is open and directed towards the meatus internus, where it forms the base of the **modiolus** or axis of the cochlea. When slit open, it is seen that from the modiolar wall there projects into the tube a bony lamina, which extends nearly half way across its lumen, dividing it partially into two parts. The membranous cochlear canal (fig. 752, Cc) is interposed between the free margin of this **lamina spiralis** and the outer wall of the whorl, and this completes the separation, so making the cochlea into a triple coiled tube (fig. 753). The free edge of the lamina spiralis presents two lips—a lower towards the lower compartment, and an upper towards the upper.

The segment below the lamina spiralis is called the scala tympani because it comes in relation to, although it does not communicate with, the cavity of the tympanum through the **fenestra rotunda**. The tube above the lamina is called the scala vestibuli because it communicates with the vestibule by a direct opening. The middle tube is the **cochlear canal**.

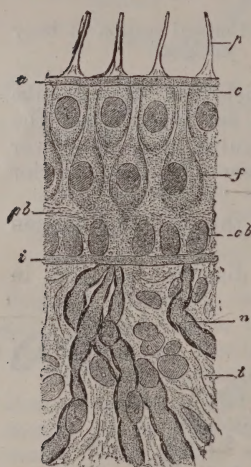


Fig. 754.—Vertical section of macula acustica—*n*, nerve fibres; *pb*, basilar plexus; *i*, epithelial cells; *r*, sensory cells; *cb*, basal cells; *f*, fusiform cells; *p*, ciliated neuro-epithelium.

The lamina spiralis does not extend quite to the upper end of the tube, but ends in a hook (**hamulus**) under the cupola to which the blind end of the cochlear duct is attached. In consequence the scalæ tympani and vestibuli here communicate in an opening, the **helicotrema**. The scala vestibuli extends to the very top of the cupola, and turning round the blind end of the cochlear duct joins the scala tympani, which ends below the hamulus.

The lower part of the lamina spiralis is broad and attached to the lateral wall of the vestibule at the beginning of the first whorl.

The fenestra rotunda or triangularis is blocked by a **membrana tympani secundaria**.

The modiolus is pierced by the cochlear part of the auditory nerve, which enters it by a number of fine openings arranged in a spiral, the **perforate spiral tract**. These traverse the axis and the lamina spiralis to the cochlear duct. The spiral shape is thus due to the linear extension of the cochlear tube and of these nerves, which have increased in number while constrained in capacity of linear extension, and the lamina spiralis is simply the projecting plate around these nerves as they pass to their distribution in the cochlear

canal. The perilymph enters through the scala vestibuli, and passes down the helicotrema to the scala tympani, but cannot escape thence as it is closed by the **membrana tympani secundaria**.

A fine opening starts from the beginning of the floor of the scala tympani and passes down to the side of the basilar surface of the petrous bone as aqueductus cochlea (p. 223); veins and lymphatics traverse it.

The **auditory nerve**, the eighth cranial nerve, divides into two parts, anterior inferior and posterior superior; the latter (vestibular nerve) divides into upper, middle, and lower branches, giving off nerves to the vestibule and ampullæ; the upper gives off branches for the utricle and fore and outer canals; the middle to the saccule and the lower to the hinder canal; the anterior inferior (cochlear nerve) joins part of the latter and enters the modiolus by the perforated spiral tract, sending its outer branches to the first whorl; the innermost to the last. The nerve forms an elongated ganglion at the base of

the lamina spiralis (the *ganglion spirale*), filling a spiral canal (*canalis spiralis modioli*) at the base of the lamina spiralis. From this ganglion the plexus spiralis extends on the tympanic side of the lamella, piercing the tympanic lip of the free border of the bony lamina spiralis. The fibres of the acoustic nerve have Schwann's and the medullary sheath, but lose these at the free border of the plexus.

In minute structure saccule, utricle, and canals are somewhat like, consisting of connective walls externally joined to the trabeculæ of the perilymphic tract, with a vitreous clear membrane within, lined by a layer of flattened epithelium, which clothes the cavity and is bathed by the endolymph. This is a derivative of the primitive cavity of invagination. The walls of the canals show internal thickenings which are also epithelium-clad.

On the saccule and on each ampulla there are thickened areas circumscribed and projecting into their cavities, each ampulla is crossed by a transverse *crista acustica*, marked externally by a slight depression. The similar spots on the inner walls of the sacculus and utricle are called *macula acusticae*. Here the epithelium is cylindrical, consisting of some cells armed with stiff hairs placed

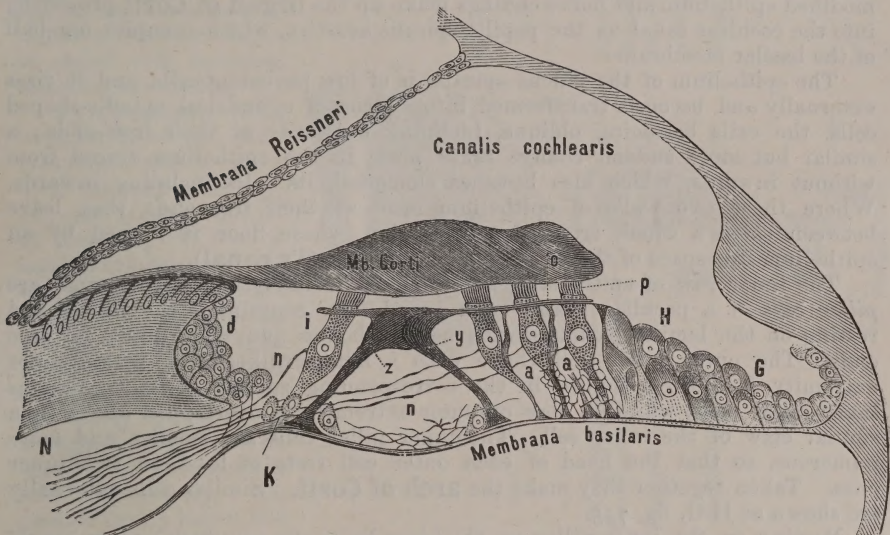


Fig. 755.—Scheme of section through the cochlear duct and organ of Corti—N, cochlear nerve; K, inner hair cells; P, outer hair cells; n, nerve fibrils, ending in the latter; a, supporting cells; d, cells in the sulcus spiralis; z, inner rod of Corti; Mb, membrane of Corti; O, membrana reticularis; H G, epithelium.

between other basal cells. These acoustic hairs project into the endolymph (fig. 754). In the endolymph of the saccule and utricle opposite there are particles of calcic carbonate, the **otoconia**, in crystalline structure resembling Arragonite (fig. 753, r).

The epithelium of the rest of the tubes shades into this sensory form; they are not abruptly sundered.

The minute structure of the cochlea is still more complex, as in it the acoustic area is prolonged as a stripe along the wall of the cochlear canal. The canal itself is three-sided rather than cylindrical, one side being attached along the outer convex wall of the bony whorl; this is the most vascular side; a second side stretches from this to form the floor of the vestibular scala, this is a thin wall, the membrane of Reissner; and a third, stretching to the tympanic

edge of the lamina spiralis, forms the roof of the scala tympani. This lower layer is that which bears the nerve endings.

The vestibular lip of the lamina spiralis (**crista spiralis**) projects freely into the cochlear canal, and the notch between the two lips (**suleus spiralis**) is filled by connective cells (fig. 755, d). The nerves (*ib.*, N) perforate the membrane along the upper edge of the tympanic side. Along the crista spiralis, are small wart-like prominences, on account of which the lip is sometimes called labium sulcatum. Along the border of this lip the elevations of the surface appear as little tooth-like prominences (auditory teeth).

The epithelium on the membrane of Reissner is polygonal pavement epithelium, a little modified on the outer or attached part of the wall which is covered with vascular projections; this epithelium covers the vascular striæ of this wall, and lies on the connective basis or ligamentum spirale.

The epithelium on the limbus spiralis forms a mosaic whose elements fill the grooves on the surface.

The wall of the tube towards the scala tympani is the most modified; its basement forms a membrane, the **lamina basilaris**, on whose inner side the modified epithelium and nerve endings make up the **organ of Corti** projecting into the cochlear canal as the papilla spiralis acustica, which occupies one-half of the basilar membrane.

The epithelium of the sulcus spiralis is of low pavement-cells, and it rises externally and becomes transformed into a series of cylindrical, spindle-shaped cells, the cells becoming oblique, inclining outwards at their free ends; a similar but more sudden change takes place in the epithelium traced from without inwards, which also becomes elongated, its cells inclining inwards. Where these two walls of epithelium meet at their free ends, they leave between them a canal, triangular in section, whose floor is formed by an epithelium-free space of the basilar membrane (**Corti's canal**).

The inner row of epithelial cells which immediately bound this canal are *pillar cells* of a peculiar shape, with broad feet, containing the nuclei and resting on the lamina basilaris, with narrow bodies and wide dissimilar free ends. The outer pillar cells have each a hammer-like head, whose inner extremity fits into a hollow in the corresponding surface of its contiguous inner pillar cells, while its claw or outer extremity is overlapped above by a similar claw of the inner cell. The inner pillar cells are smaller and more numerous, so that the head of each outer cell rests at least on two inner ones. Taken together they make the **arch of Corti**. Similar cells externally are shown at H G, fig. 755.

Resting on the inner pillar are the inner hair cells on which rests a row of fusiform support cells, graduating inwards until they merge into the epithelium. Externally are four rows of hair cells, each with a wide free end and pointed attached foot. Between these are fusiform support cells, thick below and thin above. The free ends of these cells are connected by a cuticle which forms a **membrana reticularis** around the cells.

The hair cells are usually in three rows, the apparent outermost or fourth row is a subdivision of the third. The hairs are in a regular row arrayed transversely on the cells in the inner row, but curved with their concavity outwards on the outer row.

Over the membrana reticularis is the **membrana tectoria**, a soft layer which begins thin over the crista spiralis, then thickens over the sulcus spiralis, to be lost over the membrana reticularis. The substance of the membrana tectoria is stratified but quite homogeneous; it is a form of mucous tissue which holds the otoliths.

The nerves escape through the row of holes along the labrum perforatum; they lose their medullary sheath and become pale, fine fibrillæ between the

cells of the inner part of the swollen epithelium. Some nerve fibres pass spirally to the inner hair cells, others through Corti's canal, sending filaments between the outer pillar cells to the outer hair cells. The organ of Corti stops short of the end of the cochlear canal, where the characteristic layers become aborted. Its place of development corresponds to the fundus of the lagena of the simple cochlea of birds and fishes (fig. 754).

The lamina basilaris is directly connected to the labrum perforatum. It consists of a homogeneous glass-like layer, capable of being broken up into radial fibres, under which is the connective tissue of the scala tympani. The fibres in the lining-tissue of the scala tympani are spiral, and cross the radial fibres into which the basilar membrane can be split. There is a spiral blood-vessel in Corti's canal, the *vas spirale*, a branch of the acoustic artery from the anterior cerebellar. The *zona pectinata* consists of a layer of radial stiff fascicles, thinning internally.

Tympanum. — The boundaries of the bony tympanic cavity have been already seen (p. 223), and it is best opened by removing the roof or tegmen tympani and cutting across the external auditory meatus at the tympanic bony margin. Thereby the membrana tympani, which bounds the cavity externally, is brought into view. The opening of the mastoid cells posteriorly, the glenoid cavity below, the Eustachian tube in front, and the bony internal ear internally complete the boundaries of the space.

The **membrana tympani** (fig. 758) is a

thin semi-transparent oval membrane of grey colour, fastened around the circumference of the tympanic ring. It is smooth and concave externally, with a central boss or umbo projecting, to which internally the tip of the handle of the malleus is attached. It averages 9·15 mm. high, 8·30 broad, and 0·1 thick, and has a surface of nearly 50 sq. mm. Its plane is oblique, so that the two membranes if prolonged downwards would meet at an angle of 120° beneath the base of the skull, and if prolonged forwards they would meet at an angle of 130° in front of the skull. This angle in the sixth-month fœtus was 160°, and the membrane is nearly on the plane of the top of the meatus, but the angle diminishes with age until middle life.

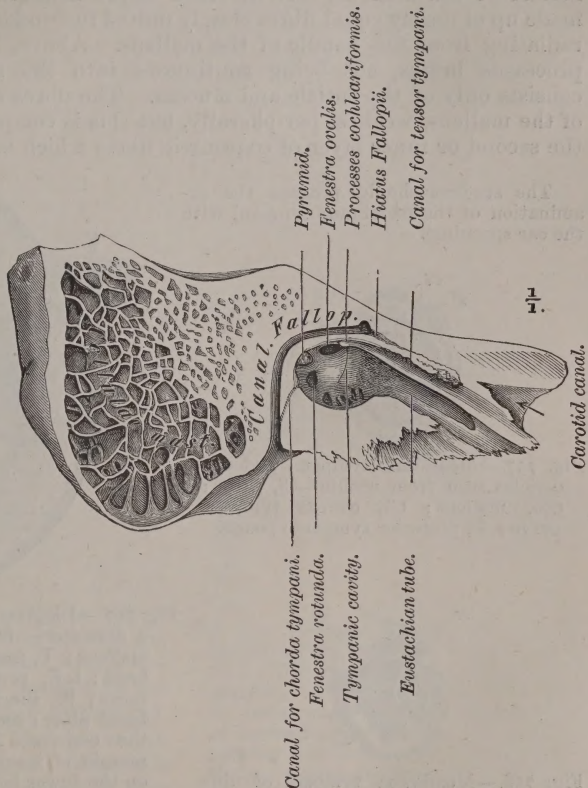


Fig. 756.—Oblique section through the temporal bone, to show the tympanic cavity and the mastoid cells.

Near its upper part the membrane is slightly projected outwards by the processus brevis of the malleus (close to *v*, fig. 758). Over this there is a weaker, outwardly pouched area of the membrane, the *pars flaccida*, often pierced by the *foramen Rivini*. This corresponds to the part of the squamosa which completes the deficiency in the tympanic ring (between *v* and *h* in fig. 758). The marginal groove of this part does not correspond to that in the tympanic ring, and the proper membrane exhibits thick borders where it surrounds this part.

The membrana tympani consists of three layers—(1) a **membrana propria** or fibrous central layer, (2) covered externally by cuticle, (3) internally by the squamous epithelium of the mucosa of the tympanum, which covers also the handle of the malleus, here attached to the membrana. The middle layer is made up of nearly equal fibres closely united in two lamellæ, an external of fibres radiating from the handle of the malleus. Above, these form arches over the processus brevis, not being continuous into the membrana flaccida, which consists only of the cuticle and mucosa. The fibres are strongest at the handle of the malleus, weakest peripherally, but this is compensated by the presence of the second or inner layer of concentric fibres which is strongest peripherally.

The student should practise the examination of the membrana tympani with the ear speculum.



Fig. 757.—Membrana tympani, and the ossicles seen from within—*ci*, incus; *cm*, malleus; *ch*, chorda tympani nerve; *T*, posterior tympanic pouch.

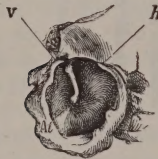


Fig. 758.—Membrana tympani of nine month fetus, seen from without—*V* and *h* are the two extremities of the bony tympanic ring.

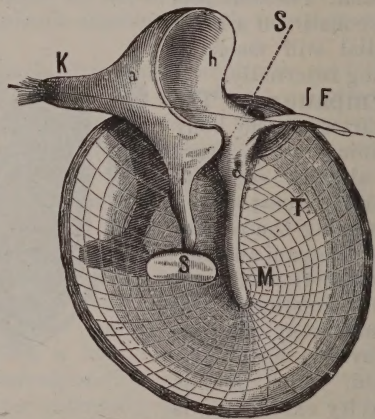


Fig. 759.—Diagrammatic view of ossicles, magnified 4 diameters—*M*, manubrium or handle of the malleus; *T*, insertion of tensor tympani; *h*, head; *LF*, processus gracilis or Folianus; *a*, incus; *K*, short leg; *L*, long leg; *S*, stapes, basal plate; *ax*, common axis of rotation of the ossicles; *S'*, raised lip on the lower margin of incus, which projects into a groove on the lower border of the articular surface of the malleus, like a tooth of a cog-wheel, locking them so that they both move together in inward motions.

The ossicles.—The malleus (fig. 760) is placed with its head directed towards the roof of the cavity which it nearly touches. The only part which is perfectly free is the neck which joins together the processus brevis and the head. External to the spot where it enters the membrane is the processus gracilis, a slender spicule of bone, ending in a fibrous thread, which projects anteriorly and downwards at right angles from the neck of the malleus, and is lost in the tissues filling the Glaserian fissure; the cartilage-clad area of the head looks backwards and enters the glenoid cavity of the incus. The handle of the malleus, which lies in the membrana tympani, is a long curved process, compressed coronally at its base, sagittally at its tip, and therefore seeming curved. It is embedded in

a thick, almost cartilaginous periosteum whereby it is tied to the membrana. The malleus has also a short process directed outwards and often a small spur for the insertion of the *tensor tympani*.

The **incus** is placed behind the malleus, and in shape resembles a bicuspid tooth; its short leg is horizontal, gristle-tipped, and lies close to the roof of the tympanic cavity to which it is tied by syndesmosis, there being a strong **ligamentum incudis posterius** ending below the opening of the mastoid cells. The long leg is directed downwards parallel to the handle of the malleus and internal to it, having its end weakly bent towards the labyrinth, and narrowing to a slender neck which bears the **os lenticulare** (fig. 760, *O.S.*), whose flattish convexity fits into a shallow concavity on the capitulum of the stapes, and is surrounded by a weak capsule. The **stapes** is placed at right angles to the long leg of the incus, its somewhat semi-elliptical foot-plate being placed transversely in the fenestra ovalis. The *crus rectilineum* is in front, the *crus curvilineum* behind, and both are joined by the **membrana obturatoria**. Each crus is channelled on its central side.

The malleo-incudal joint is a trigger joint; the articular surfaces having sharp edges gripping each other. They are covered by a thin encrusting cartilage, and invested by a tight capsule.

The malleus is tied to the wall of the tympanic cavity by ligaments enclosed in mucous folds.

From the front limb of the tympanic ring on its inner side a bony process is directed backwards and inwards, the **spina tympanica posterior**, and in front of this is a smaller process directed forwards and downwards, the **spina tympanica anterior**, both outgrowths of a ridge which projects from the inner part of the annulus, jutting beyond a groove which is directed obliquely forwards and downwards, which forms the border of the Glaserian fissure.

The spina tympanica posterior projects towards the neck of the malleus and beneath it the processus gracilis extends to the Glaserian fissure; short and stiff fibres pass therefrom to the vertical line on the malleus which extends from the processus gracilis to the head (**ligamentum mallei anterior**). Fibres ascending from the Glaserian fissure are mixed with these. Upwards the mucous membrane covering this ligament is continued as a mucous fold

to the top of the cavity, the **ligamentum mallei superius**, which varies in length with the height of the head of the malleus, and is not a true ligament. A fibrous band, the **ligamentum mallei posterius**, arising broad from the squamous bone, where it closes the tympanic ring above, passes, narrowing, to the crista mallei. The hinder fibres are straight, its anterior oblique. This and the anterior make an axis band, around whose uniting line the malleus rotates.

An **inferior ligament** consists of the slender and often very definite band of fibres from the upper and back part of the tympanic wall, which passes forwards and downwards to the end of the handle of the malleus, behind the long leg of the incus.

An **antero-external ligament** of the malleus is a specialised slip of the sheath of the tensor tympani passing to the neck of the malleus.

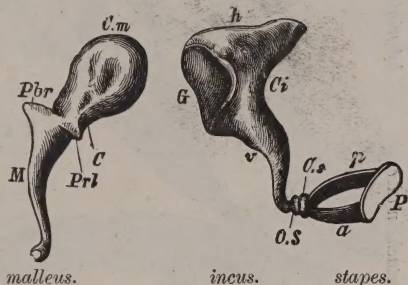


Fig. 760.—Ossicles of the right ear—*M*, handle of the malleus; *C.m.*, head; *C.*, neck; *Pbr.*, short process; *Prl.*, processus gracilis; *G.*, articular surface of incus; *Ci.*, body; *h.*, short leg; *v.*, long leg; *O.S.*, os lenticulare; *Cs.*, head of stapes; *a.*, anterior limb (*crus rectilineum*); *p.*, curvilinear or posterior limb; *P.*, basal plate, with upper convex and lower flat margin.

The stapes is fixed in the fenestra ovalis by a ligamentum annulare, under which is the continuous periosteum of the vestibule. This joint allows of a slight movement.

The motions of the bones upon each other are small in amount, and they are produced by the following muscles:—

1. **Tensor tympani** (fig. 763), occupies the upper compartment of the musculo-tubal canal, and arises from the spina angularis of the great wing of the sphenoid and from the wall of the canal wherein it lies; its tendon winds over the processus cochleariformis, passing transversely at right angles to the handle of the malleus to be inserted into the handle below the processus brevis. It draws the handle and the membrana inwards, and is supplied by a branch from the inferior maxillary division of the fifth nerve (p. 600).

2. The **laxator tympani**, occasionally present, consists of a few muscular fibres, in a mass of connective tissue, which forms the lowest part of the

anterior ligament of the malleus, attached to the spine of the sphenoid, passing through the Glas-
erian fissure to the malleus. It chiefly serves as a ligament.

3. **Stapedius**, a small penniform muscle contained in the hollow eminentia pyramidalis, from whose apical orifice its tendon emerges to be inserted into the head of the stapes posteriorly. It acts in making the basal plate of the stapes to oscillate, pressing its hinder end into the fenestra ovalis, and lifting the anterior end a little from pressing into the opening. It is supplied by a branch of the facial nerve.

The mucous lining of the tympanic cavity covers the bony walls closely, and is inseparable from the periosteum, except where nerves or vessels inter-

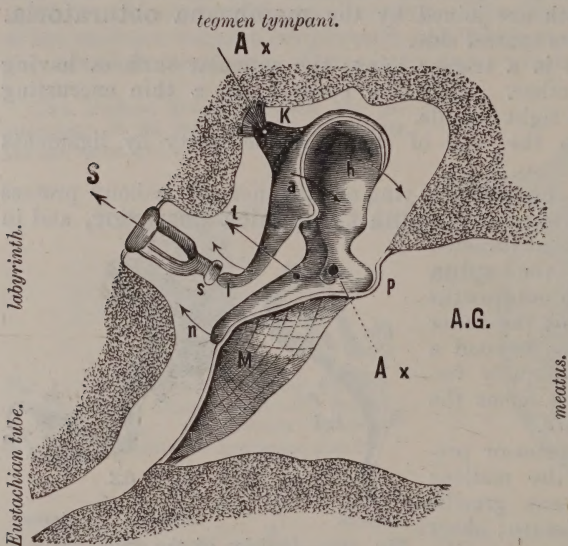


Fig. 761.—Diagram of ossicles in situ, $\times 6$ —A.G., external meatus; M, membrana tympani; n, handle of malleus; p, short process; h, head of malleus; a, incus; K, its short process and ligament; l, long process; S, os lenticulare; s, stapes; A x, axis of rotation of the ossicles, shown in perspective, oblique to the plane of the diagram; t, line of traction of the tensor tympani, which causes the other ossicles to move in the direction of the arrows.

It is continued over the secondary membrana tympani of the fenestra rotunda and over both surfaces of the obturator membrane of the stapes. It contains a few Pacinian corpuscles at its lowest part.

The mucous membrane covers also the chorda tympani nerve, forming a flat malleal fold which bounds the upper border of the two tympanic pouches, anterior and posterior. These are separated from each other by the malleus, and correspond to the membrana flaccida. This fold is called the malleal fold, and ends with a free concave border. The edge of the hinder fold surrounds the chorda tympani. The pouch bounded by this fold is deeper than the anterior, which is less conspicuous. The mucosa is thinner and less vascular towards the mastoid cells, into which it is continued, and it lines the many irregu-

lar pits, separated by bony spicules which bound the cavity below and behind.

The foetal tympanum is not an open cavity as its lining of thick mucous tissue fills its entire space. This diminishes in thickness rapidly after birth, and then the infant is able to differentiate sounds. In the adult, the epithelium consists of a single layer of low cells which become ciliated on the floor and in a few patches, and which are cylindrical towards the Eustachian tube. Simple gland pouches exist near the Eustachian tube.

The Eustachian tube, whose pharyngeal end has already been seen (p. 617), is 36 mm. long, and ascends upwards, backwards, and outwards from the pharynx to the tympanic cavity at an angle of 40° with the horizon.

It consists of a cartilaginous region of 20·26 mm., which is funnel-shaped below, and a bony tube of about 10 mm.

The cartilage is a grooved mass, incomplete downwards and outwards along its whole extent and closed here by membrane. Its lumen is a nearly vertical slit. The cartilage at first is folded above and externally, then it thickens below and internally.

The cartilage is fixed in the scaphoid fossa of the internal pterygoid process. Its mucosa is continuous on one side with that of the pharynx, on the other with that of the tympanum; it thins towards the tympanum, but at its pharyngeal end there are masses of lymphoid tissue continuous into and around it from the pharynx. The membrane here is also thicker and more vascular, and more richly provided with mucous glands. Its epithelium is ciliated columnar.

Along the floor of the tube the mucosa appears reticulated from the projection into it of netted submucous fibres, on which are small laminated bodies simulating Pacinian corpuscles.

In life it is usually almost, if not altogether, closed, but can be partly opened by the tensor palati. The action of the levator palati tends to close it.

The cavity of the tympanum is supplied by tympanic arteries (1) from the internal maxillary (p. 582), (2) from the stylo-mastoid (p. 563), and (3) from the internal carotid. Its mucosa is supplied by branches of a **tympanic plexus** which lies on the promontory (p. 224), and which is formed by (1) Jacobson's auricular branch of the glosso-pharyngeal (fig. 679, λ), (2) the two carotico-tympanic branches from the sympathetic (p. 606), (3) a branch of the great superficial petrosal (fig. 679, β), (4) and the small superficial petrosal which is connected with the otic ganglion. The chorda tympani traverses the cavity, and leaves it anteriorly through the canal of Huguier.

The **external auditory meatus** (fig. 612) begins at the deepest part of the concha and ends at the membrana tympani. It is curved with a concavity downwards, and passes obliquely inwards and a little forwards in the adult. In the foetus it was very short, even more oblique, but straight, and the curves do not begin to develop until about five years of age, before which time the membrana can be seen by pulling the ear upwards and backwards. In the adult it averages 3·1 cm. in length, 8 mm. in height, and 6·5 in breadth.



Fig. 762.—Dissection of the right stapedius muscle.

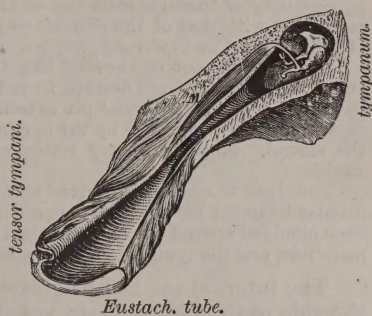


Fig. 763.—The Eustachian cartilage and tensor tympani muscle (M).

It consists of two parts—a shorter outer cartilaginous portion, and a larger inner bony. The former is oval in section, with a vertical long axis; the latter is usually elliptical, with a horizontal long axis.

The skin lining the meatus is continued from that covering the pinna, and becomes gradually thinner to the *membrana tympani*. It adheres closely to the perichondrium and periosteum, and bears at the orifice many hair-bulbs and sebaceous glands. In the deeper part of the cartilaginous portion are many large, brownish, modified sweat glands, which secrete the cerumen, or "wax"; but these **ceruminous glands** do not extend into the bony part. The vessels of the meatus are derived from the auricular branches of the temporal, internal maxillary, and posterior auricular arteries; the nerves which are most abundant at the outer part of the tube are supplied by the auriculo-temporal and the auricular branch of the vagus.

The corrugated pinna collects and reflects some sound waves, although its curves are too short to be of use for the majority of noises. The vibrations travel along the meatus to the *membrana tympani*, which is made to vibrate thereby. The attachment of the malleus acts as a damper to prevent the undue preponderance of the response of the vibrating membrane to its own fundamental note and the consequent inequality of perception, as well as to prevent the after vibrations. The chain of ossicles transfers the vibrations to the membrane of the fenestra ovalis, and thereby to the perilymph in the bony labyrinth, and they also form an apparatus whereby the tympanic membrane can be altered in tension. The axis of rotation of the bones is an oblique line passing through the short leg of the incus and emerging at the root of the *processus brevis* of the malleus close to the root of the *processus gracilis*. Around this axis the bones rotate in a plane vertical to the *membrana tympani*. The incus and stapes are placed at right angles to each other. When the handle of the malleus is drawn inwards the locking arrangement figured in fig. 761 causes the incus to move inwards with it, but when the malleus is drawn out the incus is not drawn out by it. The range of motion of the os lenticulare in such inward motion is, on account of the difference in length of the processes of malleus and incus—9.2 mm.: 6.5 mm., only two-thirds that of the tip of the malleus, the maximum movement of the latter being .07 mm. Tension of the tympanic membrane is produced by inward traction of the malleus by the *tensor tympani*; relaxation by elasticity of the ligaments and of the membrane. Motion of the *stapedius* is commonly associated with that of the *orbicularis palpebrarum*; motion of the *tensor tympani* with that of the temporal and external pterygoid muscles.

The development of the ear, like the eye, is twofold. The tympanic cavity and meatus and Eustachian tube are derived from the first visceral slit, which, however, is at its dorsal part always closed, a dermal pit externally and a pharyngeal diverticulum internally being separated from each other by the epiblastic bottom of the first and the hypoblastic fundus of the second. Some transitory traces of the rest of the cleft appear at first, but speedily vanish.

The chain of ossicles is derived from the modified hyomandibular, the hyomandibulo-mandibular ligament having partly chondrified to form the *processus gracilis*, while the stapes has been moulded around the now vanished stapedial artery, the degenerated original artery of the mandible, and the tympanic bone has been derived from the displaced and replaced quadrate.

The internal ear has originated as a superficial invagination of epiblast at the side of the hinder brain vesicle. This becomes flask-shaped, and then sinks inwards, losing its connection with the surface. The remains of the stalk of invagination is the ductus endo-lymphaticus in the aqueduct of the vestibule, and the saccus endo-lymphaticus is the remains of the most superficial part of this tube. The fundus of the flask becomes surrounded with a mesoblastic capsule, whose inner layer becomes adherent to the epiblast lining the invaginated sac, forming the membranous labyrinth, while the outer layer thickens, chondrifies, and forms the cartilaginous periotic capsule which fills in the gap at the side of the base of the chondrocranium. The fundus of the primary flask forms the utricle, and from it the semicircular canals project as outgrowths, while a ventral diverticulum gives rise to the sacculle, and subsequently to the cochlea.

CENTRAL NERVOUS SYSTEM.

538. THE CENTRAL NERVOUS SYSTEM consists from above downwards of eight parts :—

- A. The **fore-brain** or **cerebrum**, consisting of (1) the **lateral fore-brain** or cerebral hemispheres, and (2) the **inter-brain** or thalamic region (fig. 764).
- B. The **mid-brain**, consisting of the (3) optic lobes, and (4) crura cerebri.
- C. The **hind-brain**, consisting of (5) the cerebellum, (6) the pons Varolii.
- D. The **after-brain** or the medulla oblongata.
- E. The **spinal marrow**.

The best practical course for the student to pursue is to examine these from above downwards. The spinal marrow has been detached from the medulla in the dissection of the back (p. 259), but its examination is most profitably undertaken later on. The remaining seven parts are collectively called the *brain*.

The **brain** when taken out should be inspected at first from above and then from below. Seen from above, the convoluted surfaces of the two cerebral hemispheres are alone visible, as these completely conceal all other parts. The inferior surface or “**base**” of the brain is very irregular (fig. 765), and on it the following peculiarities are to be noticed. Anteriorly, the supraorbital surfaces of the frontal lobes of the cerebrum have, in grooves on their under surfaces, the two **olfactory nerves** and their bulbs (*ib.*, I), one on each side of the median fissure. Behind and external to these are the **Sylvian fissures** indenting the cerebral hemispheres, and bridged over by the arachnoid membrane as it passes on each side from the frontal lobe anteriorly to the temporal lobe which limits this fissure behind.

At the inner end of the Sylvian fissure the cut end of the internal carotid artery appears on each side, sending forwards and inwards the anterior cerebral artery into the great median longitudinal fissure which separates the frontal lobes, and sending backwards the small posterior communicating artery to join the posterior cerebral artery still farther back. The continued trunk of each carotid, the middle cerebral artery, extends into the Sylvian fissure of its own side, branching as it sinks beneath the arachnoid.

The two anterior cerebral arteries are united in the longitudinal fissure by a short transverse median branch, the anterior communicating artery, behind which the **optic commissure** projects conspicuously, formed by the median convergence of two flattish white bands, the **optic tracts**, and giving off the two diverging **optic nerves** (II), whose oval cut ends project prominently.

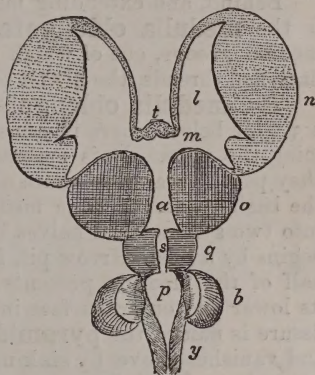


Fig. 764.—Scheme of horizontal section of brain—*l*, lateral fore-brain or cerebral hemisphere with thickened outer wall, *m*; *a*, *o*, inter-brain or thalamic region; *q*, optic lobes and crura cerebri constituting the mid-brain; *p*, *b*, hind-brain or cerebellum and pons; *y*, after-brain or medulla oblongata.

In front and above the optic commissure, on carefully removing the overlying layer of arachnoid membrane, the interval between the tracts is filled by a thin, grey plate, the **lamina cinerea**. Behind the optic commissure, a conical membranous process, the **infundibulum** (4), projects downwards and forwards; this was originally connected to the surface of the **hypophysis** or pituitary body, but was detached from it in taking out the brain; within it, is a flat perforated grey swelling, the **tuber cinereum**.

Still farther back, and lodged in a rather deep median hollow, are two little white knobs, the **corpora mammillaria** (6), placed close together, one on each side of the middle line; behind these, and still deeper, is a small triangular median plate of brain-tissue, the **posterior perforated plate** (7), traversed by many little arteries. On each side of this is a prominent, oblique, and longitudinally striated projection, the **crus cerebri** (8), lying in the interval between the inner margin of the temporal lobe, and the front and outer edge of the **pons Varolii** (9).

On the inner side of the crus, a white cord, 2 mm. in diameter, the **third** or **oculomotor nerve** appears (III). Its end has been cut in taking out the brain shortly after it has passed between two arteries, the superior cerebellar behind and the posterior cerebral in front.

The **pons Varolii**, whereinto the crura cerebri pass on each side, is a quadrate median eminence, whose inferior surface slopes obliquely downwards and backwards, grooved along its middle line for the *basilar artery*, which here passes forwards and gives off the two last named vessels on each side.

Behind, and extending medially downwards and backwards from the pons, is the **medulla oblongata** (12), separated from the pons by a transverse median groove, out of which on each side of the middle line two small white flattened threads, the **sixth** or **abducens oculi nerves** (VI), come out.

The **medulla oblongata** is flattened and pear-shaped, about 2.5 cm. long, 1.3 wide below where it joins the spinal cord, but 2.2 cm. wide above where it joins the pons. It is embraced by the vertebral arteries, one on each side, as they pass forwards to unite at the level of the hinder edge of the pons to form the basilar artery. The medulla on the anterior or basilar surface is divided into two symmetrical halves by a median groove, the **anterior fissure**, which begins by a deep narrow pit, foramen cæcum, between the sixth nerves. Each half of the medulla presents laterally two longitudinal grooves, which divide its lower and outer surface into three areas; that on each side of the anterior fissure is named the **pyramid** (10), as it expands in width from below upwards, and vanishes above by sinking under the transverse fibres of the pons. The somewhat elliptical area outside the pyramid is the lateral tract of the medulla, which for the upper half of its length expands into an elliptical swelling 1 cm. long, the **olive** (11), and the hinder portion completing the rest of the visible area of the medulla oblongata is the **restiform body**. Between the olive and the restiform body the lateral tract is continued upwards as a narrow band sunk to the bottom of the posterior lateral sulcus.

Between the pyramid and the olivary body is a groove, the *sulcus lateralis anterior*, out of which ten to twelve fine flattened nerve filaments emerge and unite into two cords forming the **twelfth** or **hypoglossal nerve** (XII). Between the olive and the restiform body is a *sulcus lateralis posterior* in which a large number, about twenty similar nerve cords, come out, and as far as they remain attached to the brain, they can be seen to be obscurely grouped into two sets, the anterior of which forms the **ninth** or **glosso-pharyngeal nerve** (IX), while the larger hinder forms the **tenth** or **vagus nerve** (X). The olive is limited below by a fascicle of fibres which loop around it from the pyramid to the restiform body, the superficial arcuate fibres.

The nerves arising from the medulla are soft at their points of emergence, and are liable to be torn from the surface when the membranes be stripped off; hence this operation should be done very carefully in this region.

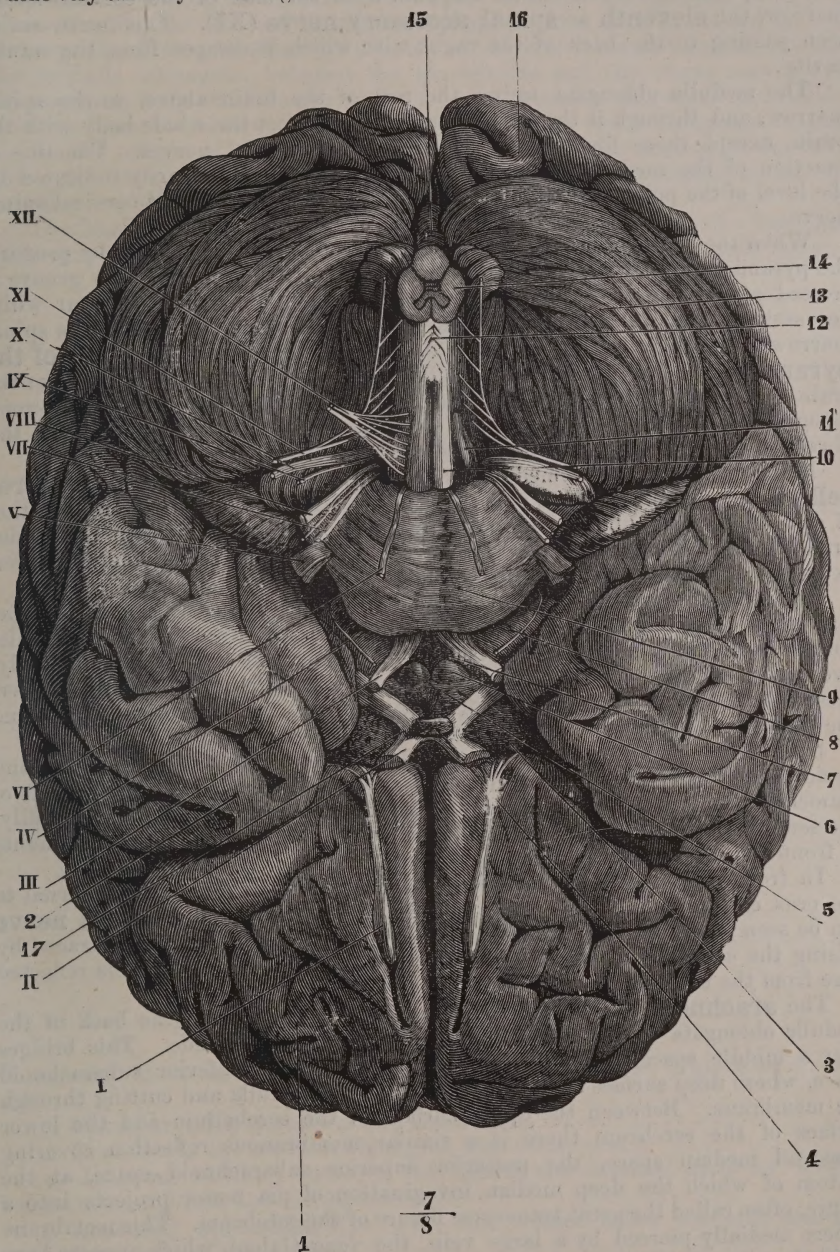


Fig. 765.—View of the base of the brain—2, temporo-sphenoidal lobe of cerebrum; 3, external perforated plate; 5, tuber cinereum; 14, cut end of medulla oblongata; 16, occipital lobe of cerebrum.

In the same groove, but lower down, nearer to the cut end of the medulla, some filaments emerge which join a cord, cut in taking out the brain, that passed up through the foramen magnum from the side of the cervical spinal marrow, the **eleventh or spinal accessory nerve (XI)**. This nerve can be seen passing to the back of the vagus with which it escapes from the cranial cavity.

The medulla oblongata unites the rest of the brain above, to the spinal marrow, and through it the fibres pass which connect the whole body with the brain, except those fibres which constitute the cranial nerves. The line of junction of the medulla and spinal cord is somewhat arbitrarily indicated by the level of the point of exit of the upper filaments of the first cervical spinal nerve.

When the anterior fissure of the medulla oblongata is opened, by pressing the pyramids apart with the handle of the knife, it is seen that this groove is crossed at the apex of the pyramid of the medulla by three or four white decussating bands passing obliquely downwards from one pyramid to the spinal marrow of the opposite side below (12). This is called the **decussation of the pyramids**. The medulla oblongata is the region wherein the fibres from the brain, which are systematically arranged with reference to function, become topographically grouped with respect to their regional distribution, hence the fibres which traverse it are intricately intermixed.

Behind and above the medulla oblongata is the lower surface of the **cerebellum (13)**, attached to the pons by an outward and backward prolongation of each side of that body, the **crus cerebelli**, and lying beneath the under surface of the hinder lobes of the cerebrum, whose posterior end, however, extends backwards, even behind the hinder edge of the cerebellum.

The surface of the cerebellum is divided by lines of nearly concentric sulci into lamellar convolutions. In the angular interspace between the medulla oblongata internally, the crus cerebelli in front and the cerebellum externally, two nerves emerge very close together and directly in front of the ninth nerve, these are the **seventh or facial nerve** anteriorly, a firm white cord (VII), and the **eighth or auditory**, the hinder, a softer, larger nerve (VIII).

Still farther forwards near the front edge of the crus cerebelli, the large and fasciculated **fifth or tri-facial nerve** escapes, easily divisible into two sets of filaments, a larger greyer bundle of about sixty filaments behind and externally, the sensory portion, and a smaller, firmer white bundle of about ten filaments in front and internally, the motor part (V).

In front of the anterior border of the crus cerebelli and lying external to the crus cerebri a fine thread-like nerve, the **fourth or trochlearis nerve** can be seen emerging from its deeper attachment, to which it can be traced by raising the cerebellum, and dividing the arachnoid membrane as it is reflected here from the cerebrum to the cerebellum.

The **arachnoid membrane** is reflected as a sheet from the back of the medulla oblongata to the cerebellum medially and on each side. This bridges over a middle space, the **vallecula (15)**, or posterior inferior subarachnoid space, whose deep surface is shown by raising the medulla and cutting through the membrane. Between the upper surface of the cerebellum and the lower surface of the cerebrum there is a similar membranous reflection covering a second median space, the posterior superior subarachnoid space, at the bottom of which the deep median invagination of pia mater projects into a fissure, often called the great transverse fissure of the cerebrum. This membrane is here medially pierced by a large vein, the vena Galeni, which appears here divided as it entered the straight sinus (p. 532).

Vessels of the brain.—This is the most convenient time to examine the distribution of the arteries to the surface of the brain. The cut mouths of four

large arteries can be seen, the two **carotids** (fig. 766, 1) and the two **vertebrals** (*ib.*, 9). Each of the latter, which have been seen arising from the subclavians (p. 550), as they ascend on the sides of the medulla oblongata, gives off **anterior** (10) and **posterior spinal** arteries already noticed (p. 552) and a **posterior cerebellar** (11), which winds backwards and outwards round the medulla oblongata, between the hypoglossal and the vagus nerves over the restiform body and into the vallecule; here it passes backwards and divides into two branches, internal and external; the former coasts along and supplies the hinder margin of the cerebellum, and along the inner surface of the vallecule; the latter turns outwards on the under side of the cerebellum to join the superior cerebellar close to the outer margin.

The **basilar artery** formed by the median junction of the two vertebrals (14) equals the pons in length, and lies on the clivus occipitalis under cover of

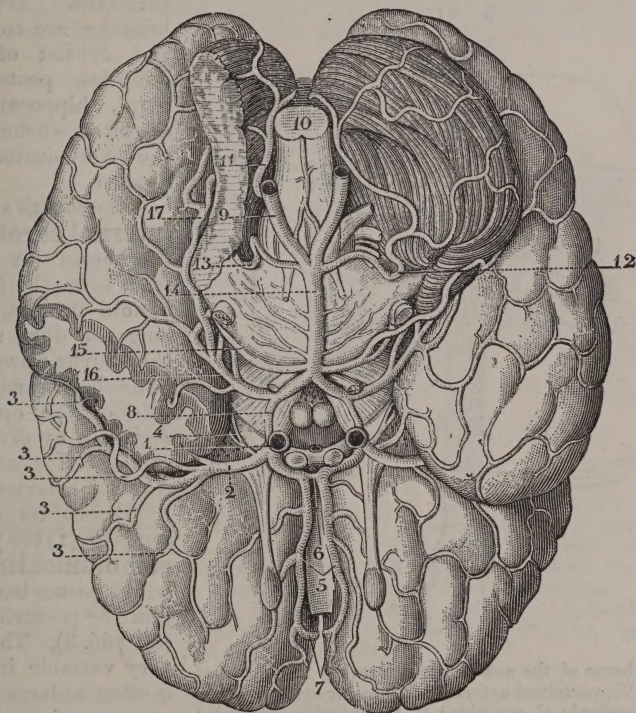


Fig. 766.—View of the arteries on the base of the brain

the arachnoid membrane. Before its anterior termination it gives off on each side:—

1. Pontal arteries, numerous and transverse;
2. Branches to the medulla oblongata, also transverse;
3. Internal auditory artery; this enters the internal auditory meatus between the seventh and eighth nerves;
4. **Anterior cerebellar** (12, 13); this crosses below the crus cerebelli to the front edge of the organ.

The basilar artery on the level of the pretentorial opening ends by dividing into two pairs of branches:—

5. The **superior cerebellar** passes behind the third nerve outwards and

backwards around the front edge of the cerebellum to the upper surface of the organ to the optic lobes and choroid plexus, anastomosing on the surface with the other cerebellar arteries (15);

6. The **posterior cerebral**, the largest branch of the basilar, passes outwards in front of the third nerve and rises above the edge of the tentorium (16). It is joined in front by the **posterior communicating** artery from the carotid (8), and then turns backwards to supply the lower and inner surfaces of the occipital and temporal lobes of the cerebrum; close to its origin it sends (A) three sets of ganglionic branches—(1) postero-median, which pass through the posterior perforated plate to the walls of the third ventricle and to the optic thalamus; and (2) posterior choroid, which pass through the transverse fissure to the choroid plexus. Beyond its junction with the posterior communicating it sends (3) postero-lateral branches to the outer part of the thalamus. Its terminal

branches are cortical (17), and consist of cuneate, occipital, posterior temporal, hippocampal, and dentate branches to supply the convolutions so indicated.

The fourth stage of the **internal carotid** reaches the brain by emerging from beneath the anterior clinoid process, and piercing the dura mater. It then turns upwards and a little backwards on each side of the optic nerve, and ends by dividing into the anterior and middle cerebral arteries (p. 680).

Before its division it sends off (1) the **posterior communicating** artery, which passes backwards to join the posterior cerebral (fig. 766, 8). This vessel is very variable in size, and is often so large that it appears as if the latter was its continuation, and as if the basilar stem of this vessel was only a collateral

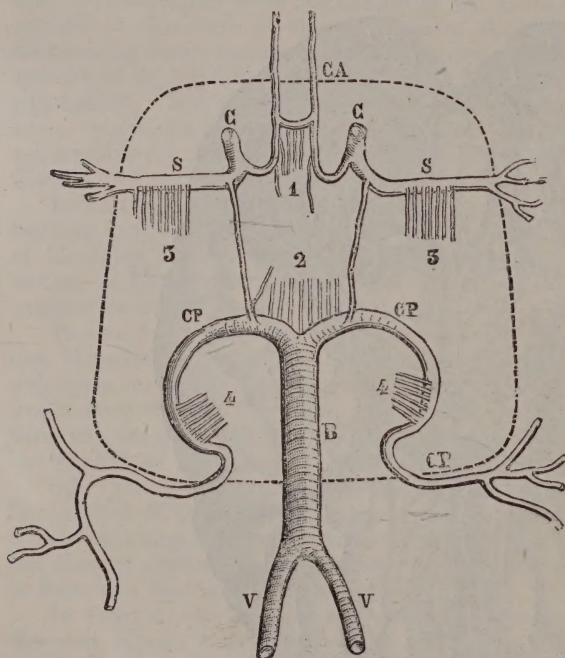


Fig. 767.—Scheme of the anastomosis forming the circle of Willis—V, V., vertebral arteries; B, basilar artery; C.P., posterior cerebral; C, carotids; C.A., anterior cerebrals; S, middle cerebral; 1, anterior perforating arteries; 3, arteries of the posterior perforated space; 2, arteries of the corpus striatum; 4, posterior nutrient arteries.

channel. In its course along the inner side of the uncinate gyrus it sends branches thereto, and a middle thalamic artery, which ascends to the optic thalamus above it.

(2) The **choroid** artery passes beneath the edge of the uncinate gyrus and enters the lateral extremity of the transverse fissure to end in the choroid plexus (*ib.*, 4).

The **anterior cerebral** artery passes forwards and inwards on the under side of the frontal lobe of the cerebrum between the olfactory and optic nerves (5). It then enters the longitudinal fissure in front of the genu of the corpus callosum, and, lying on that commissure, at first ascends, and then turns back-

wards on the floor of the longitudinal median fissure, whose lateral wall it supplies (7). At its basal part it gives off antero-median ganglionic branches, a small cluster of fine arteries, which pierce the lamina cinerea and the anterior perforated plate, and supply the fifth ventricle and the inner surface of the caudate nucleus. As the artery lies in front of the optic commissure it is joined to its fellow by a short transverse trunk, the **anterior communicating** (6), which often gives off some of the antero-median arteries, as well as a small branch to the anterior extremity of the callosal-marginal convolution. The terminal branches are—(1) small callosal branches to the corpus callosum; (2) frontal; (3) paracentral; and (4) parieto-occipital, which supply the parts indicated by the names.

The large vessels just described form at the base of the brain the boundaries of an arterial heptagon, the **circle of Willis** (fig. 767), whose sides are formed in front of the division of the basilar artery by the posterior cerebral, the posterior communicating, the side of the carotid, the anterior cerebral, and the



Fig. 768.—Scheme of the distribution of the branches of the middle cerebral artery seen in a coronal section behind the optic commissure—I., area of supply of anterior cerebral artery; II., area of supply of middle cerebral artery; III., of posterior cerebral artery; V., lateral ventricle; P, pillars of fornix with septum pellucidum above them; C, caudate nucleus; Ch, optic commissure; B, optic tract cut through; L, lenticular nucleus; E, external capsule; I, internal capsule; T, claustrum; R, insula; 1, internal carotid artery; 2, middle cerebral; 3, anterior cerebral artery; 4, lenticulo-striate arteries; 5, lenticular arteries; 7, infundibulum.

anterior communicating arteries. This and the other superficial anastomoses are important, because (1) there are no other communications between the ganglionic branches and the cortical; (2) nor between the several ganglionic or other vessels which pierce into the brain substance. All these are end arteries, and have no marginal anastomoses with their neighbours other than the minutest. The other superficial anastomoses are—(1) the parieto-occipital between branches of the anterior and posterior cerebral; (2) Sylvian, between branches of the middle and posterior cerebral arteries; and (3) frontal, between branches of the middle and anterior cerebrals.

The arachnoid membrane covers the circle of Willis and its environs, which region is the most extensive of the subarachnoid spaces. On removing the membrane, the lamina cinerea, the optic commissure, the tuber cinereum, and the infundibulum and posterior perforated space appear included within the circle.

The **middle cerebral artery** is the terminal branch of the internal

carotid (fig. 766, 2), and passes outwards into the Sylvian fissure. From its inner surface there arise two or three small caudate arteries, which pass through the inner part of the floor of the Sylvian fissure to the head of the caudate nucleus; external to these are the antero-lateral arteries, which pass through the anterior perforated plate, and are distributed to the internal capsule and the outer part of the caudate nucleus. Still farther out is a larger branch, the lenticulo-striate artery (fig. 768), which, piercing through a hole by itself at the outer part of the anterior perforated plate, is distributed to the lenticular nucleus. This has the unenviable notoriety of being the most frequently ruptured artery in the brain. At the border of the insula, the middle cerebral artery divides into four branches (fig. 766, 3, 3, 3, 3), which ramify on the brain surface—(1) frontal; (2) opercular branches to the operculum; (3) temporal; and (4) angular branches—to the parts of the surface to which these names are applied.

The area of supply of each vessel is fairly definite; the minute ganglionic vessels frequently present miliary aneurisms of their coats and are very liable to disease, as probably no vessels in the body are exposed to greater and more sudden variations of blood pressure. The pathological fact that embolic clots most frequently occlude the left middle cerebral artery cannot be explained on any theory of more direct exposure, but must depend upon some physiological condition correlated with the greater motorial activity of the left side.

The veins of the brain substance do not accompany the arteries, and are about two and a quarter times more capacious than the arteries. Those visible on the surface, leaving the brain to empty into the sinuses, are:—

(A) **Superior cerebral veins**, about eight in number on each side, ending in the superior longitudinal sinus (p. 532). These communicate freely with each other from before backwards and are usually frontal, paracentral, central, and occipital. (B) **Inferior cerebral**, which pass from the base of the cerebrum and the borders of the Sylvian fissure. The foremost of these empties into the inferior longitudinal sinus and cavernous sinus, the hindmost into the lateral, close to the parietal angle, one usually joins the superior petrosal; one large vein (vena anastomotica) from the outer surface of the operculum passes forwards and joins the cavernous sinus under the lesser wing of the sphenoid; it often communicates with the superior longitudinal sinus also, by joining the vein of the posterior frontal convolution; one hinder vein winds round the crus cerebri and joins the vena Galeni near its end. The **cerebellar veins** are (A) superior, which join the venæ Galeni and the under side of the straight sinus, and (B) inferior, which join the occipital sinus centrally and the origin of the sigmoid sinus laterally.

The **venæ Galeni**, whose cut mouths have been already noted, are the chief outlets for the venous blood of the parts bounding the ventricles. There are no valves in the intracranial veins.

The vessels in the brain are surrounded by perivascular and parietal lymph sheaths (p. 88), which act as lymphatic channels and carry the lymph to the brain surface; here they communicate with the great subarachnoid and subdural spaces, which are really great lymph spaces, and from which the lymph is carried back into the circulation. There is also a perineural lymph sheath around every nerve.

Remove the arachnoid and pia mater from one hemisphere of the cerebrum and place the brain, base downwards, on a bed of tow, wet with spirit, on a plate.

539. THE CEREBRUM is an ovate mass, making up six-sevenths of the whole brain, divided into two hemispheres by a median longitudinal fissure (fig. 769), whose floor is formed by the great transverse commissure, the **corpus callosum**. The surface consists of grey nerve matter, and is irregular, either raised into tortuous gyri, the convolutions, or depressed into involutions or fissures. By this arrangement the superficial area is enormously extended, and

the actual surface is five and a-quarter times what it would be were the surface smooth. By this arrangement the size and area are enormously extended. The convolutions are generally symmetrical in plan on the two sides, although there is rarely an identity in detail. It is doubtful how far there is a constancy of position of any given group of nerve cells, but it is possible that, while each group occupies a definite position with regard to its neighbours, yet on account of the varying development of the several areas, the absolute sites of each group are not quite as constant as their relative positions, and that a group which in one brain occupies the crest of a convolution may be in another on the slope or even in the trough between two gyri.

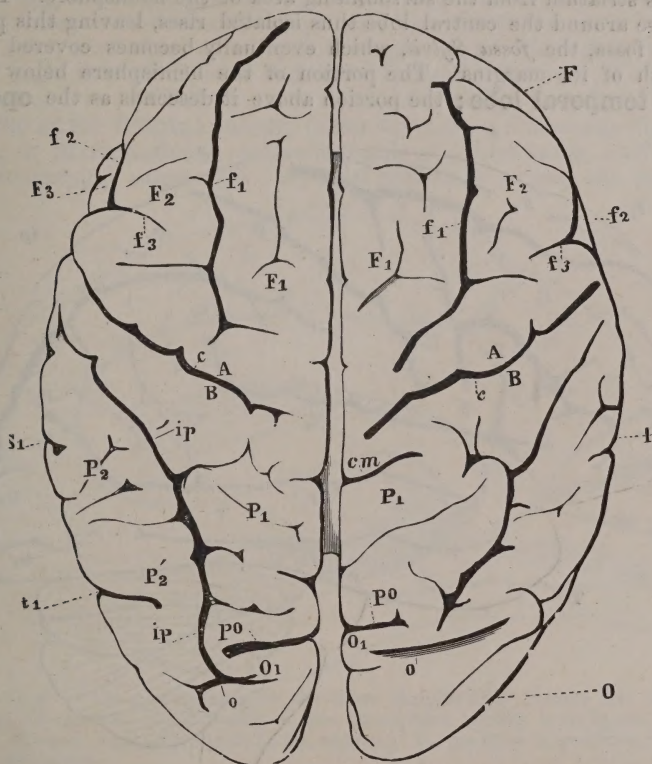


Fig. 769.—View of the convolutions of the upper surface of the cerebrum—F, frontal lobe; P, parietal lobe; O, occipital lobe; A.B., opercular lobe. The convolutions are marked with capitals, the fissures with minuscules.

The depths of the sulci and the patterns of the convolutions are expressions of the relative rates of growth of different areas of the surface; their order of development in the individual is an interesting historical indication of the progressive evolution of the successive areas. Certain infoldings are early and constant, and form important land-marks, dividing the surface into areas called *lobes*. It must be borne in mind that these are only surface markings, and have only a morphological significance as far as they are expressions of the rates of growth of definite areas of cells.

The fissures of primary importance on the cerebral surface are :—

I. The **median longitudinal**, dividing the two hemispheres, floored by the corpus callosum.

II. The **incisura pallii** or interval between the cerebrum and cerebellum, though really not a fissure in the strict sense of the word yet is often described as the great transverse fissure of the cerebrum, it indents the cerebrum posteriorly between the hemisphere and the thalamic region and into it is interjected that great pouch of pia mater the **marsupium cerebri** or choroid plexus and velum interpositum. Its existence is due to the back-folding of the cerebral hemispheres over the inter-brain.

III. On each hemisphere the most important fissure is the **Sylvian** (fig. 770, s). This is tripartite, and has originated in the beginning of the fifth month by the formation of a sulcus marking off the part of the brain surface external to the corpus striatum from the surrounding area of the hemisphere. The ring of hemisphere around the central lobe thus isolated rises, leaving this part as the floor of a fossa, the *fossa Sylvii*, which eventually becomes covered in by the overgrowth of its margins. The portion of the hemisphere below rises and forms the **temporal lobe**; the portion above it descends as the **operculum**,

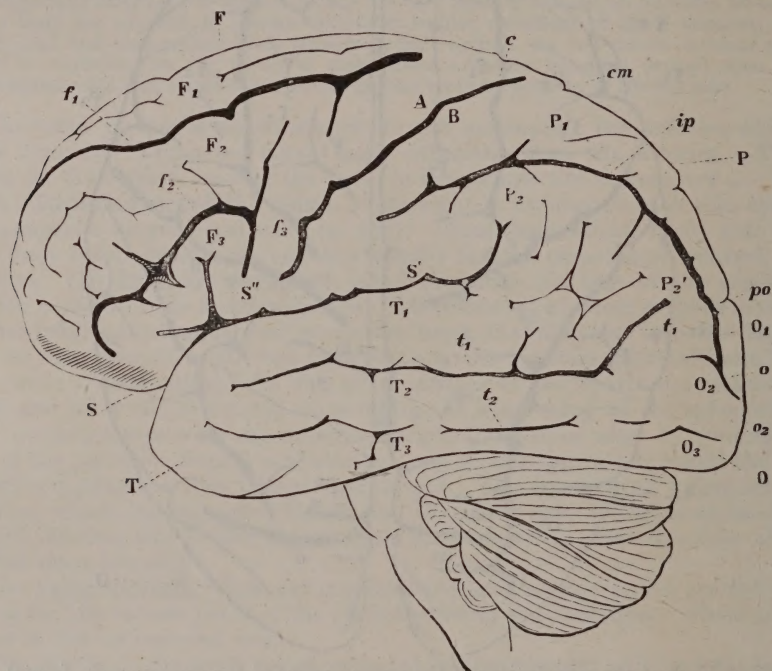


Fig. 770.—View of the convolutions on the outer side of the left cerebral hemisphere—references as in last.

and lies on the face of the central lobe, coming in contact below with the temporal lobe, and forming with it the two lips of the Sylvian fissure S' , while the part in front (**frontal lobe**) grows backwards and completes the covering in of the central lobe.

The Sylvian is thus really a system of three fissures—a longitudinal or temporo-opercular, a short anterior transverse or fronto-opercular, and a hidden, sagittally placed, vertical fissure, the operculo-insular, continued upwards from the [deep surface of the temporo-opercular.

IV. The **calloso-marginal** fissure on the internal surface of each hemisphere (fig. 771, *cm*) can best be seen at a later stage when the upper part of one hemisphere is removed. It begins anteriorly at the front and lowest end of the

corpus callosum (*ib.*, CC), and ascends at first forwards, then turns backwards, finally ascending to the upper surface of the hemisphere in the region of the obelion, at the edge of the great longitudinal fissure (fig. 769, *cm*).

V. The **parieto-occipital** sulcus, also on the inner surface (fig. 771, *Po*), begins superiorly at the edge of the longitudinal fissure behind the callosomarginal (fig. 769, *Po*) and descends on the inner surface of the hemisphere behind the level of the posterior end of the corpus callosum.

VI. On the outer surface of the hemisphere a deep **sulcus centralis** (Rolandian) passes coronally from the neighbourhood of the longitudinal fissure outwards, forwards, and downwards, in the middle of the operculum, but not communicating either with the Sylvian or the longitudinal fissures (fig. 770, *c*).

In the interval between these primary fissures there are a number of secondary sulci, much less definite, and in some sort collateral to them; two such sulci begin near the Sylvian end of the Rolandian fissure in the operculum, one in front and one behind, but neither communicating with it. The former of these, the **outer frontal sulcus**, passes upwards and forwards (fig. 770, *f₂*); the latter, or **intraparietal**, passes upwards and backwards, ending behind the parieto-occipital sulcus (*ip*). A third secondary sulcus, the **superficial**

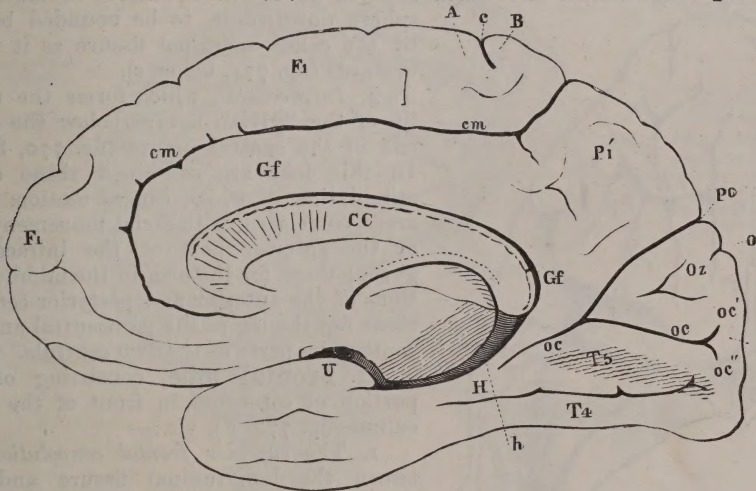


Fig. 771.—View of the convolutions on the inner (longitudinal fissure) side of the right cerebral hemisphere, the left side of the hemisphere having been taken away—CC, corpus callosum sagittally divided; Oz, cuneus; T₄, fusiform convolution; T₅, lingui-form convolution.

temporal, indents the temporal lobe parallel to the lower edge of the Sylvian fissure (*ib.*, *t₁*); a fourth, the **calcarine** (fig. 771, *oc*) extends horizontally backward to the hindmost part of the hinder lobe on the inner surface, communicating with the parieto-occipital, and stretching also forwards in front of this towards, but not to, the crus cerebri; a fifth, the **hippocampal**, coasts in a curve along the edge of the transverse fissure, of which, indeed, it is the lateral part (fig. 771, *h*); a sixth, or **olfactory**, holds the olfactory nerve beneath the frontal lobe (fig. 765, *I*); and external to this a seventh group of fissures, somewhat like an oblique broken H with curved sides, the **supraorbital sulci**, marks the under side of the frontal lobe (fig. 772, *TR*).

An eighth, the **internal frontal** (fig. 769, *f₁*), lies roughly parallel to the longitudinal fissure in front of the central lobe and internal to the external frontal fissure; a ninth, or **inferior temporal**, lies below and parallel to the superior temporal fissure, and is often double (fig. 770, *t₂*); a tenth, or **occipito-**

temporal, lies below this on the under side of the cerebrum as it overlaps the cerebellum, extending from the hinder part of this surface forwards to the front of the temporal lobe (fig. 771, over T_4).

An eleventh fissure, often irregular in length and connections, appears at the end of the interparietal as a coronally directed slit, the **external occipital**.

Besides these there are numerous irregular tertiary fissures, scarcely worthy of separate names, as they are inconstant and usually unsymmetrical.

By these fissures the cerebral surface is mapped out into lobes, the lobes divided into primary convolutions, and these still farther and more irregularly divided. The lobes are:—

I. Opercular, the area around the central or Rolandian fissure (fig. 770, A B), consisting of the following convolutions:—

1. *Precentral* (ascending frontal), which forms the anterior lip of the central fissure (fig. 770, A).

2. *Postcentral* (ascending parietal), which forms the hinder lip of this sulcus (*ib.*, B).

3. *Paracentral*, or the bridge separating the inner end of the central fissure from the longitudinal, and which extends on the inner surface of the hemisphere downwards, to be bounded behind by the calloso-marginal fissure as it turns upwards (fig. 771, below c).

4. *Infracentral*, which forms the upper lip of the Sylvian fissure below the outer end of the central fissure (fig. 770, S'' S'). In this lobe are contained those areas, stimulation of which causes motion. The areas correlated with facial movements are at the anterior part of the infracentral gyrus; those for the arm in the middle portions of the anterior and posterior central; those for the leg in the paracentral and the contiguous parts of the two centrals.

II. Frontal lobe, consisting of the portion of cerebrum in front of the operculum (fig. 770, F), viz.:—

1. The *superior frontal convolution* between the longitudinal fissure and the superior frontal sulcus (*ib.*, F_1).

2. The *middle frontal* between the superior and middle frontal sulci (*ib.*, F_2).

3. The *inferior frontal* between the inferior frontal sulcus and the anterior Sylvian fissure (*ib.*, F_3), around which it is continued by a process, the transitive gyrus, to join the precentral, with which all these three convolutions are continuous. The superior

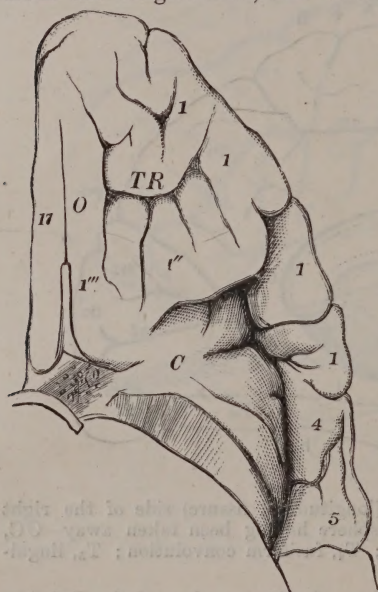


Fig. 772.—View of the convolutions on the under side of the frontal lobe, the operculo-insular fissure being opened between C and 1, 4, 5.

frontal is continuous round the front end of the cerebrum with the gyrus rectus or convolution which lies internal to the olfactory nerve on the under side (fig. 772, 17). The middle is continuous with the inner supraorbital convolutions which lie between the olfactory and the supraorbital sulci (fig. 772, O, 1'''), the inferior with the external supraorbital convolutions (*ib.*, 1, 1'').

III. The parietal lobe is small and consists of:—

1. The *precuneus* or convolution on the inner surface between the calloso-marginal and the parieto-occipital fissures (fig. 771, Pi).

2. The *superior parietal* convolution, the continuation of this on the outer surface of the cerebrum to the interparietal fissure (fig. 770, Pi).

3. The *inferior parietal* or angular convolution, which lies below the interparietal fissure, and which surrounds the upper extremity of the Sylvian fissure, joining (4) the *supramarginal* (fig. 770, S') in front to the superior temporal below and behind (fig. 770, P₂, P₂').

5. The *callosal convolution* or *gyrus cinguli* which lies between the callosomarginal convolution and the edge of the corpus callosum (fig. 771, Gf). This is an errant, forward continuation of this lobe, embracing the corpus callosum. By some this convolution, together with the structures about the septum pellucidum and the olfactory nerve, are regarded as a separate lobe, the limbic.

IV. **Temporal lobe**, or that below the Sylvian fissure, consists of four or five nearly parallel convolutions, the *first*, *second*, *third*, and *fourth temporal*, separated from each other by the first, second, third, and fourth temporal fissures. These are confluent anteriorly, and the innermost, or that internal to the occipito-temporal sulcus is continuous, not only with the occipital lobe behind, but with the callosomarginal above. As this ends anteriorly in a hook-like process, it is called the *uncinate gyrus* (fig. 771, U).

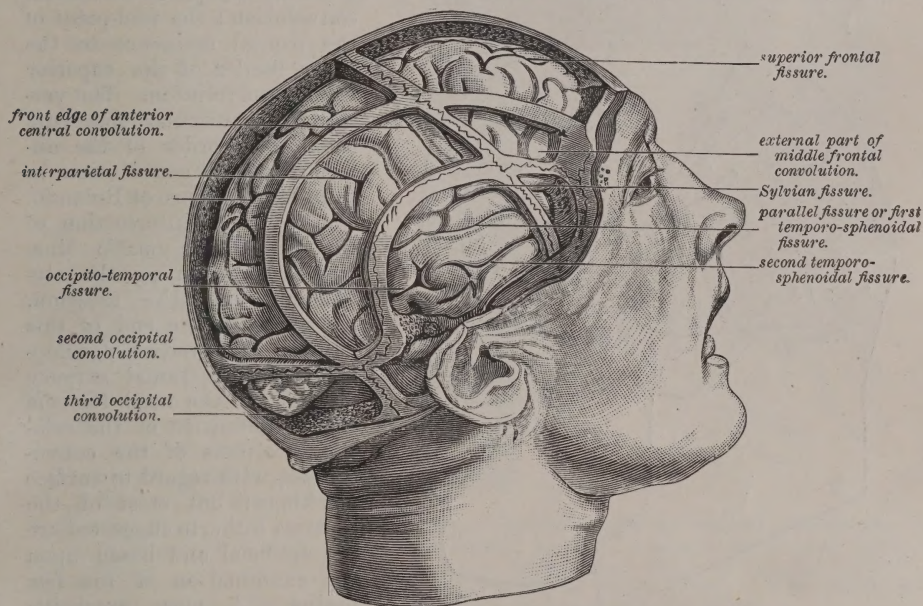


Fig. 773.—Drawing of cast prepared by Professor Cunningham to illustrate cranio-cerebral topography. Drawn by kind permission of Professor Cunningham.

V. **Occipital lobe**, marked off from the parietal by the parieto-occipital fissure internally, but only imperfectly isolated externally by the variable external occipital fissure. The portion between the parieto-occipital and the calcarine sulci appears as a wedge on the inner surface of the hemisphere, and is called the *cuneus* or internal occipital convolution (fig. 771, Oi). A very obscurely marked *middle* (fig. 770, O₂) and an *external occipital* (fig. 770, O₃) convolution can sometimes be distinguished, formed by those portions of the occipito-temporal and inferior temporal convolutions which lie behind the level of the external occipital fissure.

VI. The *lobus centralis* or *insula* (fig. 772, C), shown by separating the lips of the Sylvian fissure, is marked by four slightly diverging fissures marking out five convolutions, *first*, *second*, *third*, *fourth*, and *fifth* of the central lobe.

None of these lobes are isolated; indeed, the limits of the lobes are largely arbitrary, those of the convolutions being also artificial. The lobes are specially united by certain bridging convolutions. Thus, the three frontal convolutions by their hinder ends are confluent with the precentral convolution. The opercular lobe is joined to the parietal above and below the interparietal fissure. The parietal and occipital are joined at the upper and outer point of the parieto-occipital fissure by a superior annectent gyrus, which join the superior occipital and the interparietal convolutions. The angular gyrus unites with the middle occipital by a second annectent gyrus and with the external occipital by a third below. This last-named convolution is united to the second temporal convolution below the parallel sulcus by a fourth annectent gyrus; a fifth annectent gyrus lies on the lower surface, passing from the lower part of the third occipital to the third temporal (fig. 771, T₄).

540. CRANIO-CEREBRAL TOPOGRAPHY.—The mid-point of the parietal eminence corresponds to the supramarginal gyrus behind the posterior central convolution; the mid-point of the frontal eminence to the outer border of the superior frontal convolution. The vertical interauricular line cuts the lower border of the anterior central convolution in front of the fissure of Rolando. The point of intersection of the auriculo-bregmatic line, with a line joining the stephanion and the asterion, marks the lower end of this fissure. The recent development of intracranial surgery has led to the need for the clearer definition of the relative positions of the convolutions, with regard to surface markings; but most of the systems hitherto suggested are too artificial and based upon the examination of too few brains. A more extensive experience shows that the relation of the convolutions to surface markings are variable within very wide limits, not only at different ages and in the two sexes, but in different individuals of the same age and

Fig. 774.—Diagram to illustrate cranio-cerebral topography, devised by Dr. Reid, + parietal eminence; a, inferior boundary of parietal lobe; b, posterior boundary of occipital lobe. The line of the Rolandian fissure is a little too far forward, and the angle between the Rolando-auricular and the ecto-cantho-Rolandian lines is too wide; it rarely exceeds 70°.

sex. The points here given, therefore, although taken from a large number of heads, can only be relied on as average approximations. The anterior external angle of the Sylvian fissure corresponds to the pterion, and begins about 3 cm. behind and 1.4 cm. above the hinder border of the external angular malo-frontal suture, and its hinder end is placed in front of the line drawn coronally from asterion to asterion, and below the sagittal line drawn horizontally through the stephanion to cut this; its ascending limb passes upwards nearly parallel to the coronal suture and 5 mm. behind it. In general, a line drawn on the

side of the head from the nasion to the lambda corresponds to the line of the Sylvian fissure. If a line be drawn from the external angular process to the occipital protuberance, and a second from a point on the line, 3 cm. behind the former process, to a point 1 cm. below the most prominent point of the parietal eminence, it generally marks the edge of the temporo-sphenoidal lobe bordering this fissure. A line from the external angular process to the lambda is parallel to the first temporal sulcus. A line from the stephanion to the middle of the zygoma marks usually the front of the Sylvian fissure and its anterior portion.

The central or Rolandian fissure begins at a point 55.6 per cent. of the whole arc from the nasion to the inion. It descends for about 8.5 cm. in an oblique line, which, when drawn on the head, makes an angle of 65° with the sagittal median line; the commencing point being 1 cm. from the middle line. Its lower end is a little more vertical and runs in the plane of a coronal line drawn from the hinder level of the top of the concha, when the ear is drawn as far forwards as possible, to its fellow of the opposite side. The anterior central convolution occupies the strip 2 cm. wide in front of this. The parieto-occipital fissure runs outwards at right angles with the median line 5 mm. in front of the lambda, and the calloso-marginal reaches the surface opposite the obelion. The student should practise drawing these lines on the skull and on the living head.

The superior frontal sulcus starts from the level of the supraorbital notch, and extends to 1 cm. in front of the Rolandian line.

In skulls of different shapes these lines are liable to be displaced — generally speaking, the line of the Sylvian fissure is higher in the child than in the adult, and higher in the female than in the male. The Rolandian fissure is farther back in the infant at birth; both fissures form smaller angles with the horizontal plane in dolichocephalic than in brachycephalic heads. In correlating these structures it must be remembered that the three factors of skin marking, bone processes, and brain convolution, are all liable to independent variations, although definite areas of brain surface and of bone surface are usually correlated; but the student can easily ascertain the usual relations by the simple method of making several trephine holes at marked spots on the surface, and marking the brain surface so exposed. All systems of definite measurements must be taken with limitations.

The interparietal fissure begins on the line carried across the head in the coronal plane from the hinder border of the root of one ear cartilage to that of the opposite; starting 1 cm. above the Sylvian line, it forms a curve

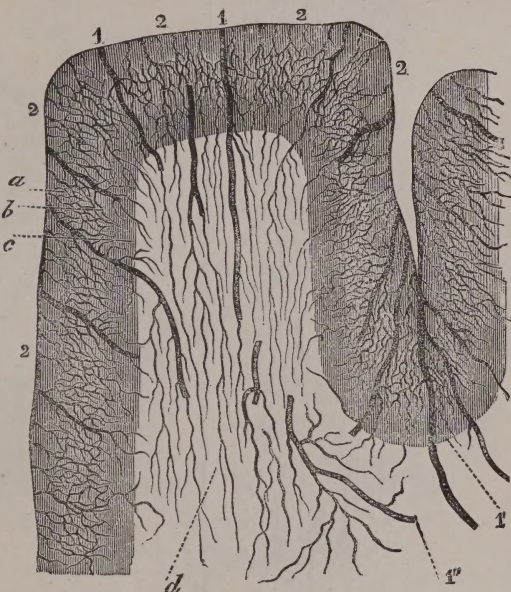


Fig. 775.—Vascular supply of cerebral convolution—1, medullary arteries; 2, arteries of the grey cortex cerebri; a, wide-meshed plexus in superficial layer; b, closer plexus in middle layer; c, wide plexus in deep layer; d, vessels in white matter.

concave downwards, and ends midway between the lambda and the parietal eminence.

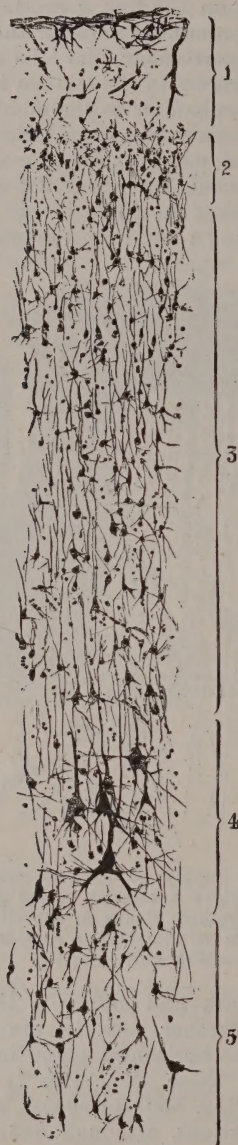


Fig. 776.—Cortex of central lobe—1, superficial layer, with only a few scattered cells in much neuroglia; 2, a layer of closely-set small pyramidal cells; 3, layer of large pyramidal cells; 4, a narrow layer of granular ganglionic cells, with large pyramidal cells in cell clusters; 5, a layer of fusiform branched cells lying parallel to surface of convolution; 6, the white substance.

541. MINUTE STRUCTURE OF CEREBRAL CORTEX.—In structure a convolution of the cerebrum consists of a grey cortex and a white core (fig. 775). The cortex is about 3 mm. thick, and, even to the naked eye, appears obscurely stratified, darker and lighter bands alternating on the face of a section.

A section shows the following layers (figs. 776, 777):—

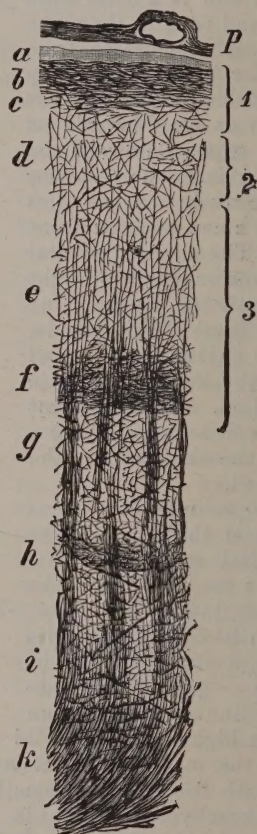


Fig. 777.—Vertical section of frontal convolution—*P*, pia mater; *a*, neuroglia; *b*, medullated fibres parallel to surface, and tangential to curve of convolution; *c*, decussating medullated fibres; *d*, layer of small cells, with netted medullated fibres; *e*, layer of large pyramidal cells, with interstitial radial bundles of medullated fibres; *f*, dark band, dense at *h*; *i*, medullated white fibres, continuous with those of *k*, the white nerve matter.

1. A superficial layer of neuroglia beneath the pia mater, and of supporting processes elongated therefrom. This layer contains near its surface an interrupted layer of medullated nerve fibres, mostly fine, and running parallel to the surface; a few pyramidal small cells are scattered among the deepest of these fibres, and a loose-meshed capillary plexus pervades it.

2. A stratum of small, closely-packed angular cells. This layer is said to be thicker in the so-called sensory convolutions, and its deeper portion is traversed by a plexus of white fibres, which are arranged in interlacing bundles.

3. A thicker layer of larger pyramidal cells, whose pointed extremities are directed towards the surface. They are in many layers in the opercular lobe,

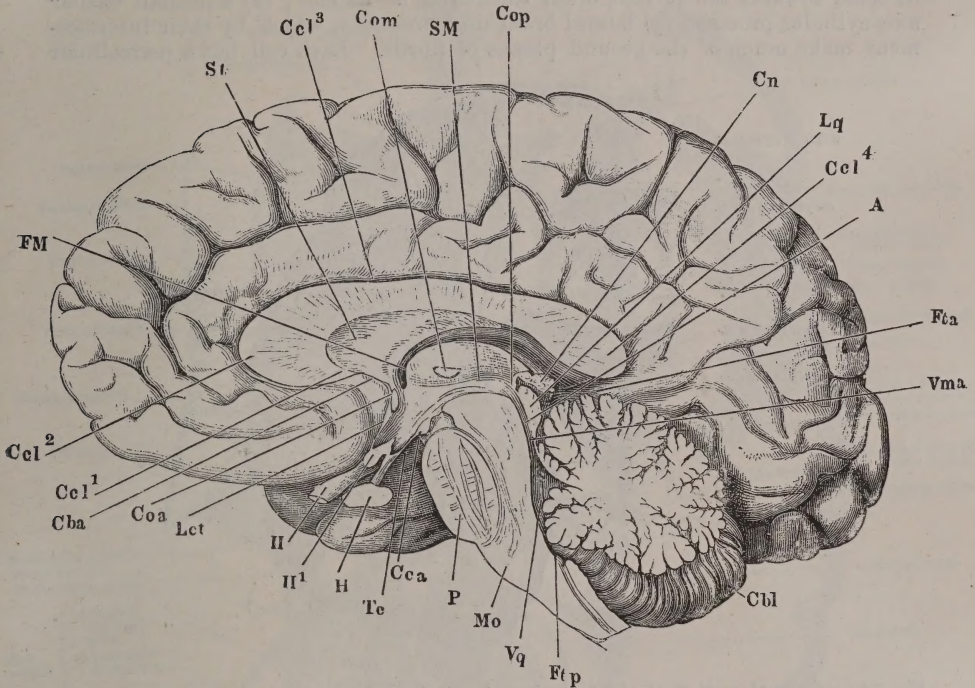


Fig. 778.—Median sagittal section of brain—FM, foramen of Monro; Ccl¹, rostrum of corpus callosum; Ccl², genu; Ccl³, upper surface; Ccl⁴, splenium of corpus callosum; Cba, peduncles of corpus callosum; Coa, anterior commissure; Lct, lamina cinerea terminalis; II, optic nerve; II¹, chiasma cut through; H, pituitary body; Tc, tuber cinereum; Cca, corpus mammillare; P, pons; Mo, medulla oblongata; Vq, fourth ventricle; Ftp, vallecula; Cbl, cerebellum; Vma, valve of Vieussens; Fta, incisura pallii; A, Sylvian aqueduct; Lq, optic lobe; Cn, pineal body; Cop, posterior commissure; SM, sulcus of Monro; Com, soft commissure; Sl, septum pellucidum.

in which the deeper layers of cells are the larger. The cells are separated by granular matter, traversed by bundles of radially disposed medullated fibres. In the occipital region there are few very large cells, and the series is divided into two parts by an intermediate layer of granule-like cells. In the opercular and hippocampal convolutions there is a deep layer of very large branched cells (ganglion-cell layer). This layer is traversed by a close-meshed capillary plexus of blood-vessels, and at its base is a dense network of white fibres, giving the appearance of a light streak between two dark bands. The differences observed in different regions are largely in the relative abundance of the cells, not real differences of kind, as far as has been as yet ascertained.

4. Beneath this is a narrow granular layer of small branched cells with, especially in the motor convolutions, a few larger cells, around which clusters of smaller cells are accumulated. Here the white fibres traversing the layer are thicker with increased number of radial fibres, and the tissue is pierced by a wider meshed plexus of capillaries.

5. The deepest layer is one of fusiform, branched cells, under which is the white matter, whose fibres lose their myeline as they enter the cortex and radially pass between the cells.

The cells characteristic of the cerebral cortex are pyramidal, of very varying sizes (fig. 776, 4); each cell presents—(1) an apical process, often long and directed towards the surface, often thickening at its end; (2) a median basilar axis-cylinder process; (5) lateral branching processes, which by their interlacement make much of the ground plexus of fibrils. Each cell has a pericellular

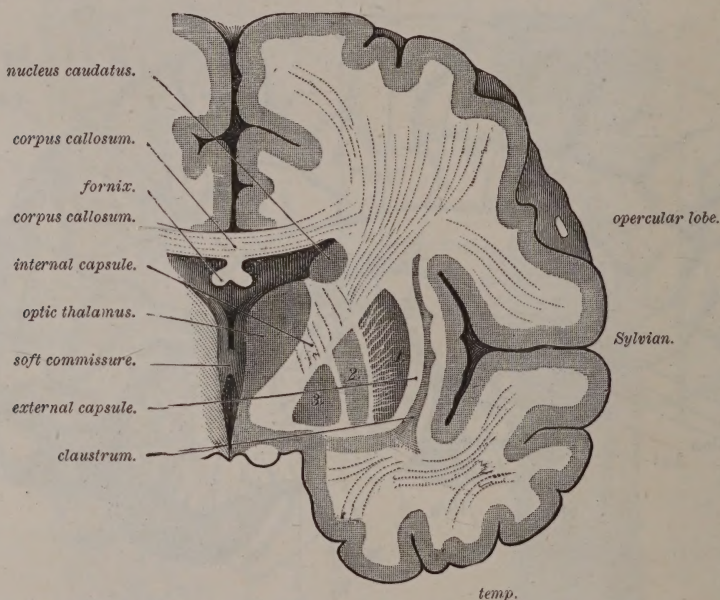


Fig. 779.—Coronal section of right cerebral hemisphere in front of the soft commissure, hinder fragment—1, putamen of lenticular nucleus; 2, 3, globus pallidus.

lymph space around it, and each vessel has a perivascular lymph sheath. The cortex is pierced by medullary arteries passing through it to the white matter, but each branch passing in from the pia mater is independent of its neighbours (fig. 775).

The **white matter of the cerebrum** consists of flattened bundles of medullated fibres passing in many directions, whose fascicles may be grouped into the following series:—

A. Short fibres from one cerebral convolution to its neighbouring gyri around the floor of each involution.

B. Longer fibres passing from one convolution to another on the same side. Of these there are several sets—

1. The cingulum, a white band in the gyrus cinguli connecting this convolution to the hippocampal and uncinate gyri.

2. The arcuate fascicle, passing from the operculum over the lenticular nucleus to the temporal lobe.

3. The inferior longitudinal fascicle in the occipito-temporal convolution.
4. The uncinete fascicle passing from the olfactory nerve backwards to the uncinete gyrus, external to the anterior perforated plate. Its inner continuation within the brain cavity appears as—
5. The fornix, to be traced subsequently.

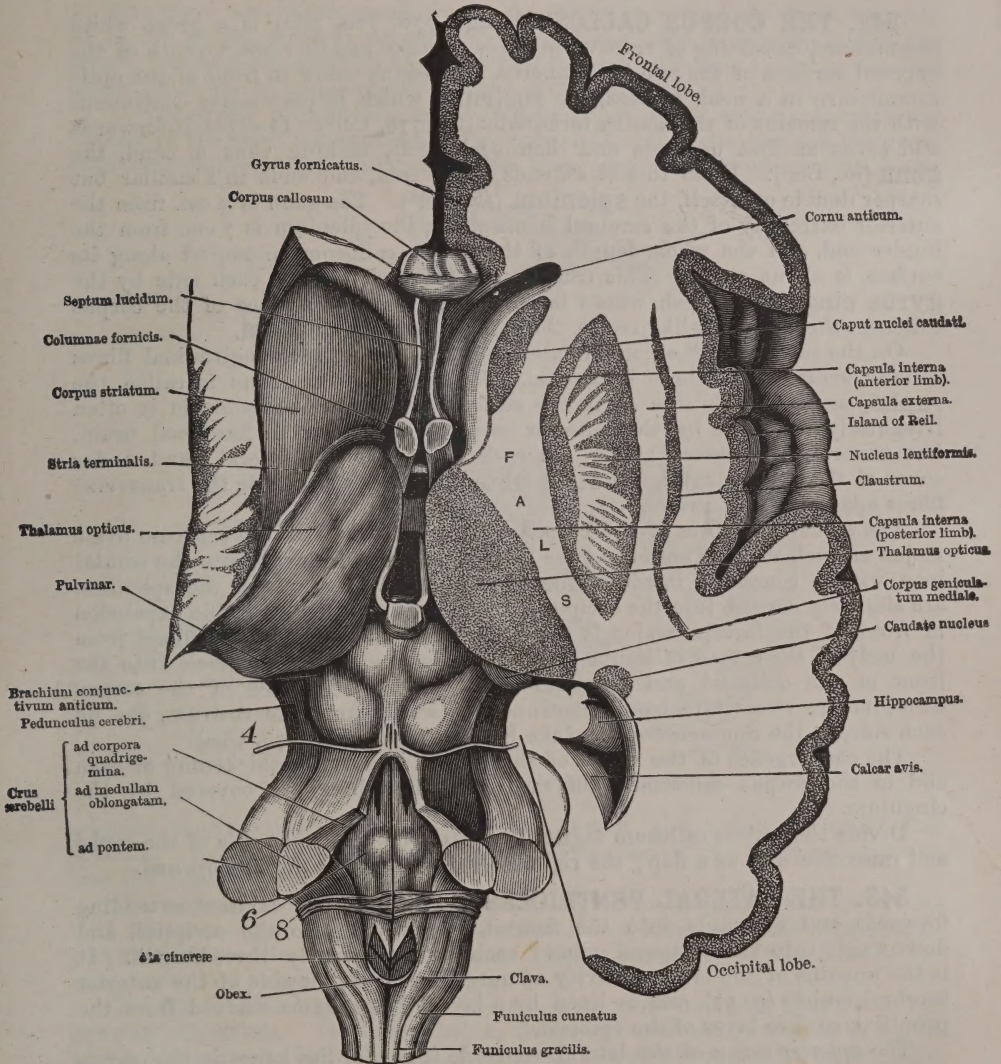


Fig. 780.—Horizontal section of cerebrum, showing the floor of the lateral ventricle on the left side, and the structure of the corpus striatum and optic thalamus on the right.

C. Fibres joining one hemisphere with the other. The commissures.

D. Fibres joining the cerebral hemispheres with the deeper parts of the neural tube. These two sets of fibres cannot yet be seen.

Divide the substance of the right hemisphere horizontally a little above the level of the corpus callosum.

Thereby is shown a white central mass, the **centrum ovale minus**, surrounded by a wavy border of grey matter. By removing another slice to the level of the top of the corpus callosum, the half of the **centrum ovale majus** is brought into view, which consists of the white centre of the hemisphere centrally united to its fellow by the corpus callosum.

542. THE CORPUS CALLOSUM (figs. 778, 779, 780) is a great white commissure, consisting of transverse fibres joining together one-seventh of the opposed surfaces of the two hemispheres. It begins below in front of the optic commissure in a weak process, the **rostrum**, which is posteriorly continuous with the remains of the lamina terminalis (fig. 778, Ccl¹). It expands forwards and turns at first upwards and then backwards, making thus a bend, the **genu** (*ib.*, Ccl²). From this it extends backwards, and ends in a similar but sharper double on itself, the **splenium** (*ib.*, Ccl⁴). The genu is 3 cm. from the anterior extremity of the cerebral hemisphere, the splenium is 7 cm. from the hinder end, and the whole length of the corpus callosum, measured along its surface, is about 10 cm. This commissure is overlapped on each side by the **gyrus cinguli**, between whose lower border and the surface of the corpus callosum there is a slit-like recess, the **suleus corporis callosi**.

On the surface of the corpus callosum there are a few longitudinal fibres usually arranged in three bands (fig. 780). The median band is called the **raphé**, and on each side of it the surface of the corpus callosum is often irregularly indented by the anterior cerebral artery in the hardened brain, but never in the recent state. On each side there is a lateral band under cover of the gyrus cinguli, the **stria obtecta**. Between these the transverse fibres appear on the surface.

The transverse fibres of the corpus callosum extend into the centrum ovale majus on each side. Those from the genu are curved forwards into the frontal lobe, with a concavity inwards (**forceps minor**); those from the splenium are similarly curved into the occipital lobe (**forceps major**). The expansion in front of the forceps major is the **tapetum**, consisting of the fibres from the body of the corpus callosum expanded over the lateral ventricle into the front of the occipital and temporal lobes. The **peduncles** of the corpus callosum are two white bands continued outwards from the rostrum, one on each side, to the commencement of the Sylvian fissure (fig. 778, Cba).

The convergence of the fibres of the forceps causes the thickening of each end of the corpus callosum. On each side the fibres are covered by the **cingulum**.

Divide the corpus callosum sagittally a little on the right side of the raphé and raise that side as a flap; the right lateral ventricle is thereby opened.

543. THE LATERAL VENTRICLES are symmetrical cavities, extending forwards and outwards into the frontal, backwards into the occipital, and downwards into the temporal lobes; each is consequently three-horned. It is the remains of the original cavity of outgrowth from the side of the anterior cerebral vesicle (p. 57), and is lined by a layer of ependyma derived from the primitive surface layer of the epiblast.

The **anterior cornu** of the lateral ventricle (fig. 780) lies beneath the corpus callosum, and behind the lateral extension of its genu, and it ends in a pointed extremity directed downwards and outwards. On its floor and external wall is the front end of a large pear-shaped grey mass, the **nucleus caudatus**; internally, it is separated from its fellow by a thin partition, the **septum pellucidum** or **lucidum**.

The **body** or middle portion of the ventricle is a cavity with a curved axis extending for the length of the corpus callosum, and continued downwards and outwards, as the middle cornu, into the temporal lobe. It is roofed by the

corpus callosum and the outgoing tapetum, and presents on its floor a series of important projections. These from before backwards are (1) the hinder part of the nucleus caudatus; (2) the *tænia semicircularis*; (3) the optic thalamus; (4) the choroid plexus; (5) the fornix; (6) the *tænia hippocampi*; (7) the cornu ammonis (*hippocampus major*); (8) the *eminentia collateralis*.

The inner wall is the opening into the anterior part of the third ventricle or cavity of the cerebral vesicle and the slit-like edge of overlap where the fornix becomes adherent to the overlying corpus callosum, marking the line along which the hemisphere rests on the optic thalamus (fig. 102).

The **choroid plexus** is a rolled-up mass of pia mater, continuous with the margin of the great triangular fold interjected into this slit through the great transverse fissure of the cerebrum. The lower end of the middle cornu is the

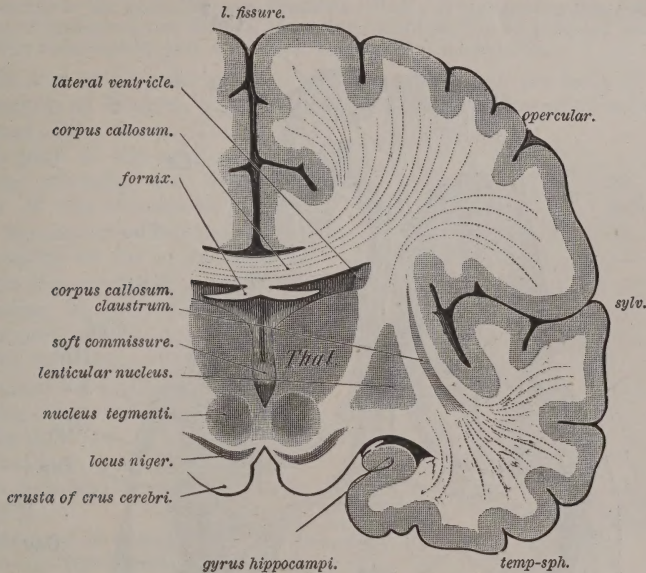


Fig. 781.—Coronal section across third ventricle.

original continuation of the ventricular cavity, and points forwards and inwards. It is the remains of the original extension of the ventricular cavity into the olfactory nerve.

The *posterior cornu* is very variable in its extent, and its axis is curved with its concavity inwards. On its inner wall is a long ridge, the **hippocampus minor**, or calcar avis, which is the inward projection of the floor of the calcarine sulcus bulging into the cavity.

The **nucleus caudatus** is the surface portion of a complex grey mass, the **corpus striatum**. It is rounded in front, and posteriorly tapers to a tail which descends into the lowest and outmost part of the ventricle, terminating in a knob.

In the groove between the nucleus caudatus and the optic thalamus is a white band, the **tænia semicircularis**, sharply margined by a thick band of ependyma (*lamina cornea*) towards the nucleus, but shading off obscurely on the thalamus. This expands outwards to be lost in the roof of the lowest part of the inferior cornu, and is continuous inwards to the lowest part of the opening from the lateral into the third ventricle. Here it terminates over a grey mass, the **nucleus amygdalæ**; under this sheath is a vein, the **vena terminalis**.

Very little of the surface of the optic thalamus is really seen in the lateral ventricle, as the choroid plexus is usually nearly in contact with the tænia.

The **fornix** is a longitudinal arch, formed by the margin of overlap of the cerebral hemisphere over the thalamus. It begins behind as a series of radiating fibres converging from the hippocampus minor, the cornu ammonis, the eminentia collateralis, and the corpus fimbriatum. These unite and form a flat converging band directed forwards and inwards, the posterior pillar of the fornix (fig. 782), which can be seen behind, turning under the edge where the forceps major passes into the corpus callosum to join its fellow medially, thereby forming the body of the fornix. The body of the fornix overlaps the thalamus, from which it is separated by the projecting border of the choroid plexus.

As the body of the fornix extends forwards it narrows, and forms anteriorly

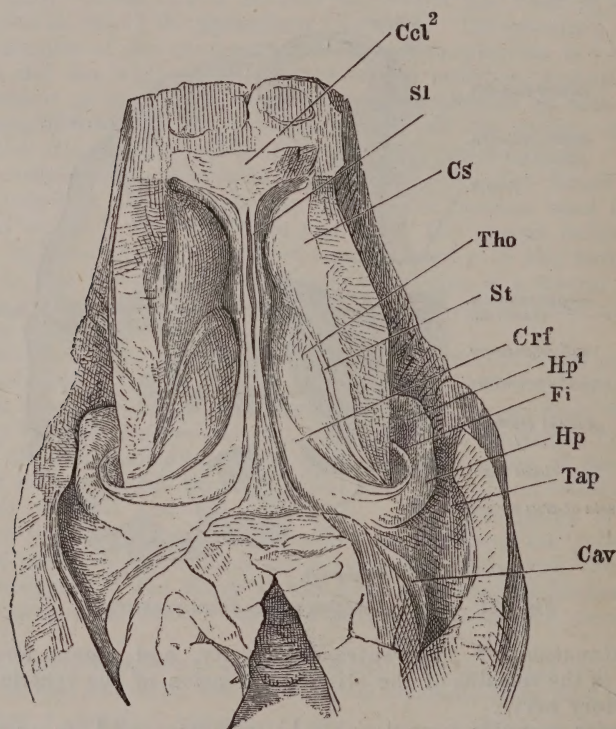


Fig. 782.—Lateral ventricles opened by the removal of the corpus callosum, whose anterior part is cut at Ccl²—Sl, septum lucidum; Cs, corpus striatum; Tho, optic thalamus; St, tænia semicircularis; Crf, posterior pillar of the fornix; Hp, hippocampus; Hp¹, pes hippocampi; Tap, tapetum; Cav, calcar avis.

two parallel white cords, the anterior pillars of the fornix, which turn downwards and finally backwards around the front of the third ventricle (fig. 780). This portion cannot be seen at present, but their terminations in the corpora mammillaria appear below within the circle of Willis.

The appearance of the fornix varies at different points of section (figs. 779, 780, 781); medially it is united to the corpus callosum for its whole length, and at its anterior portion the anterior pillars are joined to the concavity of the genu by a pair of thin lamellæ, which make the septum lucidum and completely fill the interspace.

The **septum lucidum** (figs. 778, *sl*; 782, 780), is a sagittal bilaminar

partition attached by its margin above to the under side of the corpus callosum, in front to the hinder surface of the genu, below to the upper surface of the rostrum, and behind and below to the front of the fornix. Its outline is pear-shaped, being wide in front, narrowing to a point behind. Its lateral layers are separated by a median space, the **fifth ventricle**, peculiar as being only a separated part of the interhemispheric fissure and no part of the true ventricular system. This ventricle is variable in size, but is seldom an appreciable cavity until its walls have been divaricated. It is bounded above, in front, and below by the corpus callosum, below and behind by the lamina cinerea and fornix, laterally by the layers of the septum lucidum (fig. 780). A small vein is conspicuous in its layers on each side.

The septum lucidum is formed by an infolding of the middle part of the lamina terminalis, and the ventricle is the space between the folds. There is no opening into this cavity. It has no lining of ependyma, but its wall, the septum lucidum, is a degenerated area of cerebral surface, with a rudimentary grey layer directed towards the ventricle.

Beneath and behind the anterior pillars as they join the body of the fornix is the **foramen of Monro**, whereby the lateral ventricle communicates with the anterior part of the third. This is the only open part of the original communication, whereby the cavity of outgrowth of the ventricles of the cerebral hemisphere communicated with the cavity of the anterior cerebral vesicle (fig. 102). The primitive larger opening has become narrowed by the contact of the upper lip or fornix with the optic thalamus, and the consequent flattening of the lower lip or tænia semicircularis. The space behind the foramen is filled by the choroid plexus, whose extremity extends even into the foramen of Monro (fig. 778, FM).

This foramen is bounded in front and above by the fornix, below and behind by the thalamus, while its floor is formed by the tænia semicircularis.

Where the two posterior pillars of the fornix diverge behind, a small portion of the corpus callosum appears between them, whose transverse fibres constitute the **lyra**.

The **hippocampus major** or **cornu ammonis** is the most prominent appearance in the lateral ventricle posteriorly. It is the rounded fundus of the hippocampal sulcus, and its ventricular surface is formed of a stratum of longitudinal fibres derived from the fornix (figs. 782, 783). It is moulded around the hinder border of the thalamus, from which it is separated by the lateral portion of the transverse fissure. Below, at the lowest point of the inferior cornu, it is thickened, and presents a series of external marginal digitations, the pes hippocampi (fig. 782, Hp¹). Along its inner or concave surface towards the transverse fissure it is margined by a lip composed of white fibres derived from the fornix, the **corpus fimbriatum**, which can be traced forwards and downwards to the uncinate gyrus. Where this comes in contact with the peripheral grey matter there is a coloured toothed band, the **fascia dentata**, which is the grey edge of the dentate convolution on the brain surface.

The **corpus striatum** is a much displaced, condensed, and specialised part of

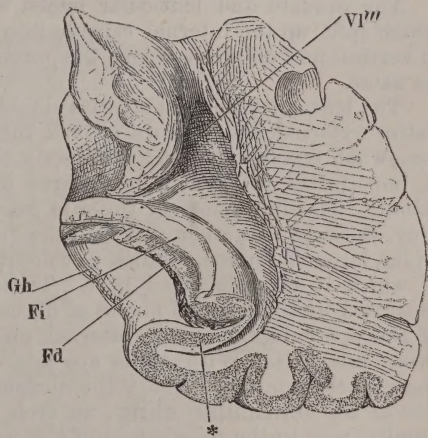


Fig. 783.—Coronal section of the hippocampal convolution—Gh, gyrus hippocampi; Fi, corpus fimbriatum; Fd, fascia dentata; VI''', posterior horn of lateral ventricle.

the peripheral grey matter of the cerebrum, and is so named because in section the layers of white fibres passing between its constituent grey masses give it a striated appearance. By making a horizontal section through it from the *tenia semicircularis* outwards to the wall of the insula, it appears to consist of five parts (fig. 780). The innermost and foremost is the **nucleus caudatus**, which appears on the floor of the ventricle, and whose head anteriorly is continuous with the peripheral grey matter of the hemisphere at the anterior perforated plate. The hinder end or tail of the caudate nucleus passes backwards external to the thalamus, and turns into the middle cornu of the lateral ventricle, on the roof of which it ends at an eminence, the **amygdaloid tubercle**.

A layer of white matter, the **internal capsule**, lies external to the caudate nucleus, separating it from the **lenticular nucleus**, which appears in this section as an irregularly bi-convex grey mass. A second white layer, the **external capsule**, separates the lenticular nucleus from a thin grey lamella, appearing linear in this section, the **claustrum**, external to which is the white matter that underlies the grey surface of the *lobus centralis*.

The caudate and lenticular nuclei are united by streaks of grey matter, which split up the internal capsule into fascicles, and hence the mass presents in vertical and oblique sections the peculiar striation from which it has obtained its name.

The lenticular nucleus appears doubly convex on horizontal section, with a flatter external and a more convex internal margin; in vertical section it is somewhat triangular. It lies directly over the external perforated plate. It is imperfectly subdivided into three parts which differ from each other in colour. The innermost of these is greyish yellow, and a middle is a darker grey, these two together make up the *globus pallidus*, external to which is the wider, larger putamen, reddish in colour, and connected to the nucleus caudatus, of which it is a detached part. These parts of the lenticular nucleus are separated by interrupted planes of fibres in part, passing from the convolutions of the operculum into the internal capsule, and from thence continued into these intervals. With these are mixed up fibres, which in part arise from these nuclei, and unite below the nucleus lenticularis to take part in the formation of the **lenticular sling**, an arch of subthalamie fibres, of which a large number pass to the tegmentum of the *crus cerebri*.

The **nucleus amygdalæ**, which underlies the corpus striatum, and projects on the upper and outer wall of the lowest part of the inferior cornu at the extremity of the tail of the caudate nucleus, is a semi-detached thickening of the cortex of the temporal lobe.

The **claustrum** is a thin lamella, an inturning of the lower part of the surface of the insula to which it runs parallel. It is directly continuous with the grey matter of the *locus perforatus*, and presents a sinuous surface bent outwards above and below.

The **internal capsule** consists of white fibres passing between the caudate nucleus and the thalamus internally and the lenticular nucleus externally; its front or *caudo-lenticular limb* joins the hinder or *thalamo-lenticular limb* at an angle, the *genu* of the capsule. The hinder limb, close to the back part of the genu, consists of the motor fibres derived from the operculum passing on through the crusta of the *crus cerebri* to the pyramid of the medulla oblongata. The fore limb consists of fibres from the frontal lobe. The hinder part of the hind limb consists of fibres from the temporal and occipital lobes separated from the frontal fibres by the pyramidal tract. These are continued through the *crus cerebri* and pons to the cerebellum; with these there also pass fibres from the cortex to the thalamus, from the cortex to the ganglionic masses in the pons; in short, almost all the fibres from the cortex to other parts of the

brain. These fibres, as they diverge above the nucleus caudatus, interlace with the fibres of the corpus callosum.

The **external capsule** is thinner, and intervenes between the putamen of the lenticular nucleus and the claustrum, but below and behind it is continuous with the internal capsule, and consists chiefly of the white fibres connected with the claustrum. The anterior limit of the corpus striatum corresponds to a line joining the stephanion to the temporal margin of the malar bone.

In connection with the cerebral hemispheres the **olfactory nerve** should be examined. This appears as a soft triquetrous process of brain matter dilating terminally into an **olfactory bulb**, which rests on the cribriform plate of the ethmoid bone, and originally contained within it a continuation of the cavity of the middle cornu of the lateral ventricle. It starts from the summit of a small pyramidal *olfactory tubercle* at the back of the sulcus rectus, and from this its **external root**, a conspicuous white streak, passes outwards and backwards across the commencement of the Sylvian fissure, and consists of fibres which pass some to the outer, some to the inner side of the uncinate

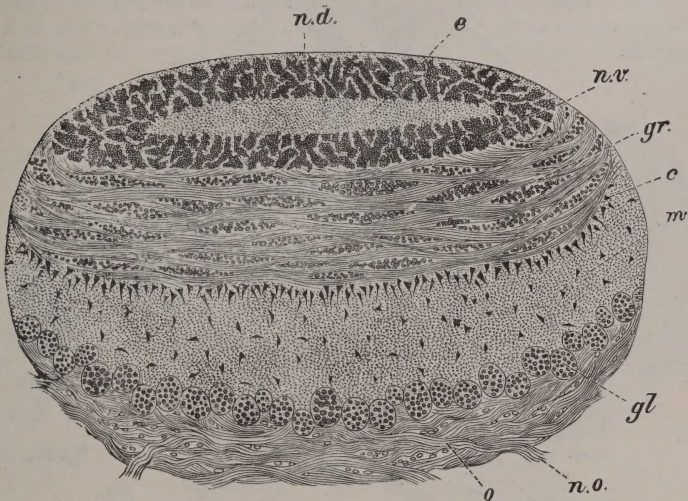


Fig. 784.—Section of the olfactory bulb, $\times 30$ —*n.d.*, dark-edged fibres cut across; *e*, granular layer; *n.v.*, a second pigmented layer; *gr.*, granular layer; *c*, large nerve cells in a clear vascular layer; *m*, molecular layer; *gl.*, granular layer, with spherical nuclei; *n.o.*, filaments of the olfactory nerves of distribution.

gyrus. This is the dwarfed remains of the pyriform lobe found in most mammalian brains. It is possible to trace fibres from this external root backwards into the hippocampus major, and through it into the fornix and corpora mammillaria, from whence they are continued by the band of Vicq d'Azyr with the *substantia innominata* beneath the anterior part of the optic thalamus; other fibres pass to the nerve from the anterior perforate plate. An inner commissural band passes inwards and backwards which crosses from one olfactory nerve to its fellow of the opposite side in the anterior border of the anterior commissure. The olfactory nerve (fig. 784) has a covering of grey substance which is thickest at its upper angle. In structure it consists of (1) the white root fibres (*ib.*, *n.d.*); (2) of a layer of ganglion cells, with which these fibres are continuous (*ib.*, *c*); (3) of a gelatinous or molecular layer, which contains cells comparable with those of the molecular layer of the retina to which this seems homologous (*ib.*, *m*); (4) a granular layer containing spherical nuclei (*ib.*, *gl.*);

and (5) the fibres of distribution, which form a tangled plexus, and are distributed to the sensory epithelium of the nose (*ib.*, *n.o.*).

Beneath the anterior end of the fornix, and behind the rostrum of the corpus callosum, is a small white transverse cord, the **anterior commissure**, consisting, anteriorly, of the crossing fibres of the olfactory nerve, and posteriorly, of transverse fibres which pass from one temporal lobe to its fellow. This commissure appears flattened and twisted at each side, but is rounded medially. It is situated in the line of the axis, around which the cerebral hemisphere appears to have become rotated in development. It should be traced to its termination into the substance of the hemisphere on one side (fig. 785, *c.a.*).

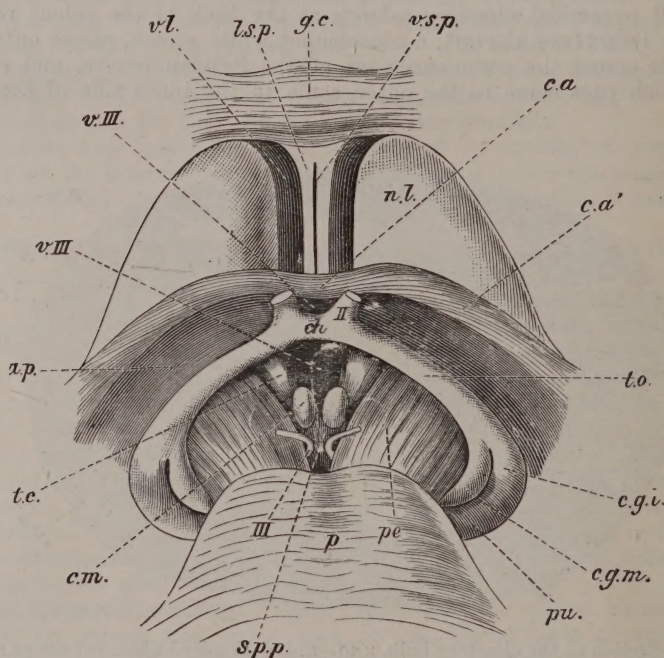


Fig. 785.—The anterior commissure (*c.a'*) and its relations, seen from below—*g.c.*, genu of corpus callosum; *l.s.p.*, layers of the septum pellucidum; *v.s.p.*, fifth ventricle; *v.l.*, lateral ventricle; *n.l.*, lenticular nucleus; *v.III*, third ventricle; *II*, optic nerve; *ch.*, chiasma; *t.o.*, optic tract; *p.e.*, crus cerebri; *t.c.*, tuber cinereum; *c.m.*, corpora mammillaria; *III*, third nerve; *s.p.p.*, locus perforatus posticus; *c.g.l.*, external geniculate body; *c.g.m.*, internal geniculate body; *pu.*, pulvinar; *p.*, pons.

Having reviewed the convolutions, the upper part of the left hemisphere is to be removed, the corpus callosum to be divided longitudinally on the other side of the median line, and its left lateral portion removed. The septum lucidum can now be seen on both sides, and should be re-examined. By slicing away the corpus callosum as it overlies the septum, the cavity of the fifth ventricle can be opened. This space has no normal communication backwards with the third ventricle, indeed, in frozen, cut brains, the two lamellæ are scarcely separated. On each side of the septum a vein runs horizontally backwards, which joins the vena terminalis directly below the foramen of Monro.

By removing the septum lucidum from its attachment to the fornix, the entire of the fornix is exposed, and should be traced from the hippocampi to the corpora mammillaria; beneath the fornix also, the foramen of Monro is visible. Now divide the fornix above this foramen and reflect the body backwards, thereby exposing the lyra on its under surface, and the extremity of the splenium corporis callosi.

The fornix rests upon the **velum interpositum**, a triangular duplicature of pia mater, which enters through the great transverse fissure, and extends over the optic thalami to the foramen of Monro, and which is continuous on each side with the choroid plexus which consists of its convoluted lateral edge.

The lower layer is the pia mater of the surface of the inter-brain, the upper is the pia of the under side of the hemisphere, but the two are inseparable, although, theoretically, the velum interpositum is a pouch open behind. An ependymal layer covers its lower surface, which forms the roof of the third ventricle, and which on each side is continuous with the ependyma of the tænia semicircularis. In the middle of the velum there pass backwards two large veins, the **venæ Galeni** (fig. 616), which are formed anteriorly by the union of the vena terminalis with the vein of the septum lucidum, and which posteriorly unite and end in the straight sinus (p. 532).

Divide the velum interpositum and its marginally attached choroid plexuses transversely about its middle, leave its hinder portion in place and remove the anterior part.

The **third ventricle** thus opened is a slit-like cavity, which was primitively the cavity of the anterior cerebral vesicle (fig. 102). It is roofed by the velum interpositum, and is bounded laterally by the inner surface of the thalamus,

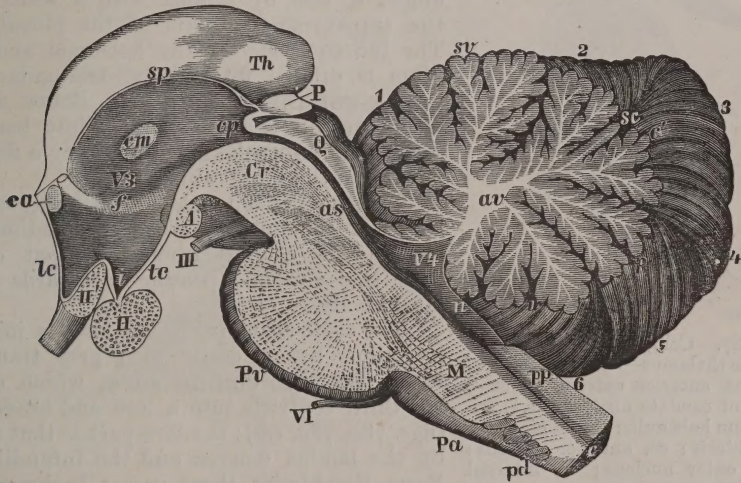


Fig. 786.—Sagittal section of third and fourth ventricles—*Th*, thalamus; *sp*, habena of pineal body; *ca*, anterior commissure; *cm*, soft commissure; *lc*, lamina cinerea; *II*, optic chiasma cut through; *H*, pituitary body; *tc*, tuber cinereum; *cp*, posterior commissure; *P*, pineal body; *Q*, optic lobes; *as*, Sylvian aqueduct; *Pc*, pons; *VI*, sixth nerve; *Pa*, pyramid; *Pd*, decussation of pyramid; *M*, medulla oblongata; *pp*, clava; *n*, inferior medullary velum; *V₄*, fourth ventricle; *av*, arbor vitæ; *sc*, folium caecuminis; *sv*, superior vermis; *V₃*, third ventricle; *f*, fornix; *i*, infundibulum.

in front by the anterior pillars of the fornix, between which, as they diverge a little below, a small part of the anterior commissure is visible. Below, the third ventricle is irregular, and floored by the conical hollow of the infundibulum in front, which descends herefrom to the pituitary body; posteriorly its floor consists of the upper surface of the tuber cinereum (fig. 786, *tc*), the upper surface of the corpora mammillaria (*ib.*, 4), and the converging surfaces of the crura cerebri (*ib.*, *Cr*), which are united by the locus perforatus posticus.

The **infundibulum** already seen from the base is walled by ependyma internally, by pia mater externally, and ends blindly in the pituitary body (p. 739).

The **tuber cinereum** consists of grey matter, and contains centrally an opening, probably the representation of the primitive terminal month of the archaic intestinal tube (*Gaskell*). Laterally, where it abuts on the optic tract, there is a mass of small nerve cells sending off fibres into the tract, and constituting what has been called the basal optic ganglion.

The **thalamus** is a large oval ganglionic mass, the upward dilatation of the grey matter of the primitive grey neural tube (p. 57). It is overlaid towards the third ventricle by a little white substance. In front, its anterior end (tuberculum anterior) bulges towards the foramen of *Monro*; posteriorly, it projects into a broader, thinner, rounded prominence towards the optic lobes, the **pulvinar**, which overlaps the inner geniculate bodies of the mid-brain (fig. 780). Below and outside the pulvinar is a small tubercle, the **corpus geniculatum externum**, a part of the thalamus, from which a large part of the optic tract originates (figs. 788, *cgl*; 790, *e*).

On the inner side of each optic thalamus is a white streak, the **crus pinealis**, outside which is a grey band, the habenula of the pineal body, passing from the ganglion habenulæ or trigonum habenulæ; beginning below and in front, and coursing backwards along its upper and inner angle, to end by joining with a white band, the transverse frænulum of the pineal body. The junction between the habenula and frænulum is dilated into a small triangular knob, the **trigonum habenulæ**. Below and attached to this is a transverse white band, the **posterior commissure**, in reality a foremost portion of the mid-brain.

These habenal bands are possibly the remains of the optic nerve of the rudimentary median eye coming from the front of the optic thalamus and passing backwards to the pineal body.

The optic thalamus of one side is joined to its fellow by an easily torn grey transverse band, the **soft commissure**, which divides the third ventricle into a fore and hinder part (figs. 780, 786, *cm*); the fore part is that floored by the lamina cinerea and the infundibulum. From the hinder there passes backwards beneath the posterior commissure (fig. 786, *cp*).

a median passage, the aqueduct of *Sylvius* (*ib.*, *as*).

The third ventricle has an interrupted grey lining of grey matter continuous downwards into the locus perforatus posticus and tuber cinereum.

Over the optic thalamus is a layer of white nerve fibres and neuroglia, the **stratum zonale**, and its interior is grey, and made up of four not very separable masses, traversed by fine, white fibres, some from the deeper part (tegmentum) of the crus cerebri, and some descending hereto from all portions of the hemisphere. These form the **radiatio thalami**, and they mix with the fibres of the internal capsule. Those from the occipital lobe are easily isolated. These radiating fibres form, with the diverging fibres of the crusta of the crus cerebri, a reticular layer on the outside of the grey central nuclei. The four grey parts (fig. 787) are—(1) the anterior nucleus, forming the anterior tubercle; (2) the posterior internal nucleus; (3) the posterior external, the largest, forming most of the pulvinar; and (4) the external geniculate body; this last is traversed by fibres passing from the thalamus to the optic tract.

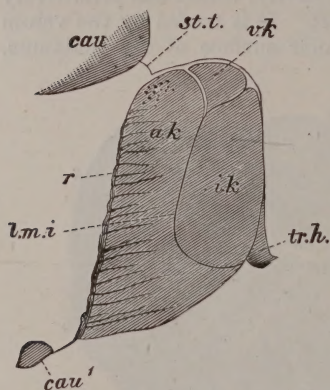


Fig 787.—Component parts of the optic thalamus—*cau*, nucleus caudatus, anterior extremity; *cau'*, tail of caudate nucleus; *tr.h.*, trigonum habenulæ; *st.t.*, tænia semicircularis; *vk*, anterior nucleus; *ak*, outer nucleus; *ik*, internal nucleus.

The optic thalamus is placed in front of a vertical line dropped from the upper end of the fissure of Rolando to the asterion. The coronal inter-tragic line limits it anteriorly.

Beneath and external to these four grey masses is the **subthalamic region**, or prolongation of the tegmentum of the crus cerebri, isolated below by an extension from the crus cerebri of the black pigmented ganglion layer of the substantia nigra. This consists of three strata:—(1) a layer of fine longitudinal fibres underlying the external posterior nucleus, called the *stratum dorsale*; (2) a *reticular formation* continued from the mesencephalon; and (3) the *subthalamic body*, a pigmented bi-convex ganglion, which again is divided into several strata. In front of this is a mixed grey and white mass of uncertain connections and boundaries, the *substantia innominata*.

Below the optic thalamus there is also the extension of a brownish grey body from the crus cerebri, the **red nucleus** of the tegmentum (fig. 781); this lies internal and above the subthalamic body.

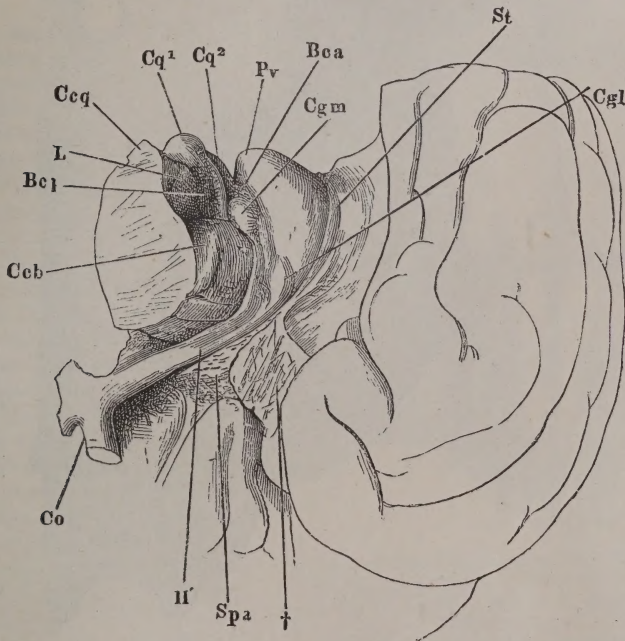


Fig. 788.—Part of the right cerebral hemisphere placed on its anterior extremity and seen from below—Co, optic chiasma; Ccb, crus cerebri; Bcp, brachium posterior; L, lemniscus; Ccq, crus cerebelli and corpora quadrigemina; Cq¹, posterior optic lobe; Cq², anterior optic lobe; Pv, pulvinar; Bca, brachium anterior; Cgm, corpus geniculatum internum; Cgl, corpus geniculatum externum; St, tænia semicircularis; †, cut end of temporal lobe; Spa, anterior perforated space; II', optic tract.

From the upper surface of the corpora mammillaria a white fascicle, the **band of Vieq d'Azyr**, ascends to the inside of the anterior nucleus, close under the grey coating of the third ventricle, by scraping through which it is easily found (fig. 786, between *f* and *A*). This is supposed to be continuous with the fibres of the outer root of the olfactory nerve, which are described as making a sharply marked angle here as they dip through the corpus mammillare from the fornix. Fascicles of white fibres also pass from the outside of the

outer nucleus across the inner capsule to the globus pallidus, and many others pass downwards to the tegmentum.

The **pineal body** (figs. 780; 786, *P*) lies behind the third ventricle above the optic lobes, embedded in the pia mater of the velum interpositum. It is a reddish-grey, flattened, conical body, with rounded apex directed backwards, and a base attached by a short stalk to a transverse white band or frenulum above the posterior commissure.

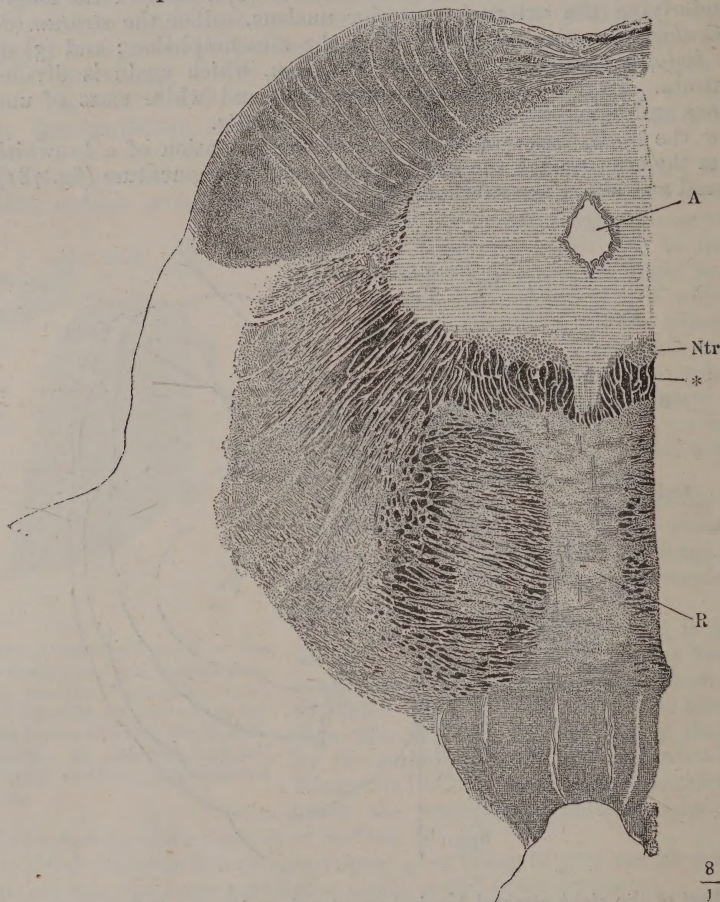


Fig. 789.—Coronal section through the anterior lobes of the corpora quadrigemina—
A, aqueduct of Sylvius; Ntr, trochlearis nucleus; R, raphe.

In structure it consists of many vessels and blind follicles filled with degenerated epithelial cells, connective granular corpora amylacea, and botryoidal concretions of calcium carbonate. This is a rudiment of a median parietal eye which probably at one time in ontogeny reached the surface. It is proportionally much larger in the fœtus than in the adult.

544. MID-BRAIN.—Below and behind the optic thalamus is the mid-brain, represented by the optic lobes and the hinder part of the crura cerebri; its cavity has diminished to form the aqueduct of Sylvius, or canal which passes backwards beneath the posterior commissure to the fourth ventricle. The

forepart of the crura belong really to the inter-brain, but it is more convenient to deal with the crus as a whole.

The **optic lobes** (fig. 780) are shown by removing the rest of the velum interpositum and pineal body. They are two pairs of eminences, the larger pair in front, the *nates*, are flatter and darker, the smaller behind, the *testes*, are more prominent and crescentic, and covered by a thin layer of white substance. In front of the former is the white posterior commissure; behind and between the latter is a cord, the **frænulum**, which joins the mid-point between the testes to the anterior medullary velum behind.

From the side of the optic lobes there pass a pair of rounded processes, the **brachia**. The brachium anterior (fig. 788, *bca*) is the smaller, and is overlapped by the pulvinar, and passes behind the pulvinar into the corpus geniculatum externum and into the optic tract. The brachium posterior (*ib.*, *bcp*) is larger, and ends beneath and externally in the corpus geniculatum internum. A third band, the fillet or lemniscus (figs. 788, *L*; 791, *f*) passes beneath the brachium posterior from the testes backwards towards the cerebellum.

The anterior and posterior optic lobes differ considerably in structure and connections. The anterior lobe consists of four distinct strata, (1) a superficial layer of white mostly transverse fibres, the *stratum zonale*, passing on the one side into the fillet, on the other into the underlying grey matter; (2) a superficial grey lamella, the *stratum cinereum*, thick and distinct medially, but becoming thinner marginally, and ultimately fusing with the thick third layer or *stratum opticum*. This is a layer of grey matter consisting of small nerve cells, and is traversed by several closely connected layers of longitudinal fibres, which are directly traceable into the brachium anterius. The fourth is a layer of white fibres directly continuous into the fillet,

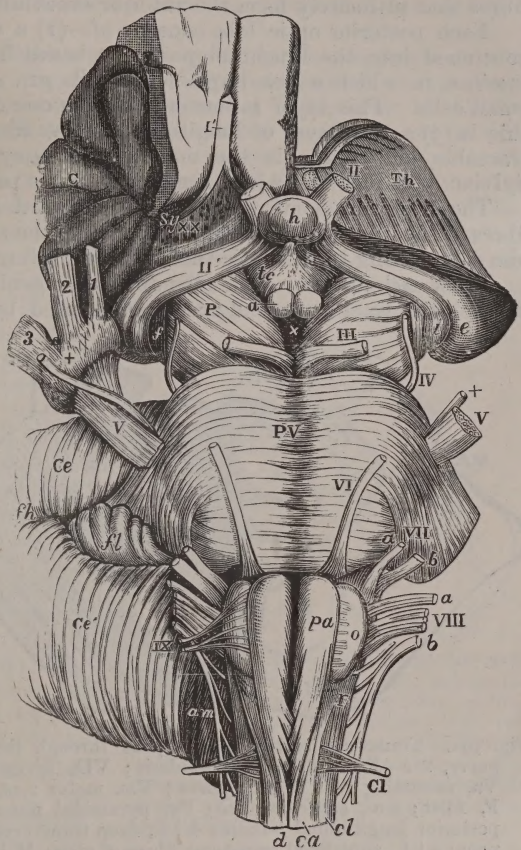


Fig. 790.—View of the pons and its relations from below —*C*, the convolutions of the central lobe; *I*, ophthalmic branch of fifth nerve; *2*, maxillary; *3*, inferior maxillary; *x* Gasserian ganglia; *V*, trunk of the fifth nerve, sensory root crossed by the slender motor root, marked on the left by +; *Ce*, lobus lunatus anterior of cerebellum; *fh*, horizontal fissure; *fl*, flocculus; *Ce'*, digastric lobe of cerebellum; *am*, tonsillitic lobe; *I*, *II*, *III*, *IV*, *V*, *VI*, *VII a*, the seven foremost cerebral nerves; *VII b*, eighth nerve; *VIII a*, ninth nerve; *VIII*, tenth nerve; *b*, eleventh nerve; *IX*, twelfth nerve; *pa*, anterior pyramid of medulla; *o*, olivary body; *Cl*, first cervical nerve; *cl*, lateral column of spinal marrow; *Ca*, anterior column; *d*, placed below the decussation of the pyramids; *e*, corpus externum; *i*, corpus geniculatum internum.

some of which blend with the optic nerve fibres of the stratum opticum, especially along the external side. Internally this layer becomes thinner and the fibres cross to the anterior optic lobe of the other side. This fourth layer rests on the grey layer of the aqueduct of Sylvius, from which also it derives fibres that ultimately form the anterior brachium.

Each posterior optic lobe consists of—(1) a *stratum zonale* of white fibres; continued into the brachium posterior, beneath which is a large grey mass or *nucleus*, in which a few large nerve cells are scattered through the mass of small cells. This layer is continuous from one optic lobe to its fellow. Under this is (3) a thin layer of longitudinal nerve fibres derived from the fillet, and traceable under this is the mass of the grey matter which surrounds the Sylvian aqueduct into which some of its fibres pass.

The posterior commissure is the forward extension of the commissural fibres of the fillet which decussate in it from the tegmentum of the crus cerebri of one side passing to the optic thalamus and internal capsule of the other.

From each anterior optic lobe and outer geniculate body many of the fibres of the optic tract arise, and are supplemented by others immediately from the

optic thalamus (figs. 788, 790). From the tract a broad bundle of fibres has been traced, through the optic radiation, backwards into the hindmost part of the occipital lobe, which is supposed to be the sensory visual area. Other important connections of the fibres of the optic tract have been traced from the fibres of the anterior limb of the internal capsule, which pass into the ansa lenticularis below and in front of the substantia innominata, and which join the tract

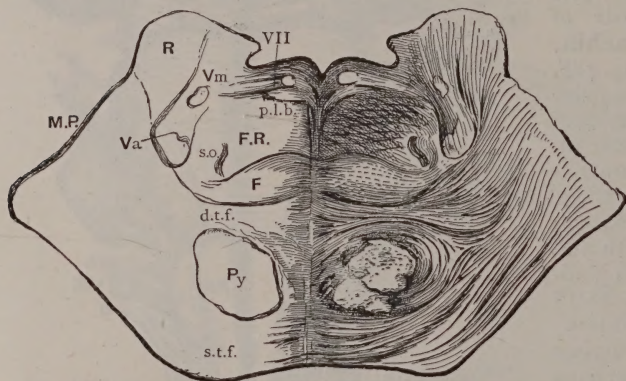


Fig. 791.—Transverse section of the pons through the seventh nerve, $\times 2$ —F.R., formatio reticularis; VII, seventh nerve; Va, ascending root of fifth nerve; Vm, motor root of fifth; F, fillet; s.o., superior olive; Py, pyramidal fibres; p.l.b., posterior longitudinal bundle; d.t.f., deep transverse fibres of pons; s.t.f., superficial transverse fibres of pons; M.P., middle cerebellar peduncle; R, restiform body.

close to the decussation, where it is also joined by fibres from the tuber cinereum. The optic tract winds round the crus cerebri and converges to meet its fellow in the chiasma (fig. 790). Here the fibres nearest the concavity of the union, which are derived from the inner geniculate body, pass from side to side as an intercerebral commissure. In the optic commissure the whole nerve crosses, no part being distributed to the eye of the same side.

The course of the optic tract has been already traced on the base of the brain; from the commissure the nerve passes outwards and forwards to the optic foramen above the ophthalmic artery.

The **crura cerebri** are two large pedicles consisting of the collected fibres, whereby the cerebrum is connected with the other parts of the brain (fig. 790, P). Each presents a furrowed surface, due to its division into fascicles, and starts beneath and behind the thalamus to enter the pons Varolii.

When one crus is coronally divided a black layer (fig. 792), the **locus niger**, is seen to cross it; this appears as a horizontal band, and it divides the crus into

a superficial inferior part, the **crusta**, already seen on the base of the brain, and a larger inner upper part, the **tegmentum**, which lies close to the floor of the Sylvian aqueduct. The crusta of one side is quite distinct from that of the other; the tegmenta are medially united. On the inferior surface the line of exit of the third nerve marks the boundary between the crusta below and the tegmentum above (fig. 792).

Along the upper border of the plane of union of the tegmenta is the Sylvian aqueduct (figs. 786, as; 789, A; 792, **Aq**), a canal about 17 mm. long, triangular in section at its thalamic end, and somewhat T-shaped at its hinder and lower extremity. This canal is lined by a ciliated ependyma and is surrounded by a vascular grey layer, 2 mm. thick, continuous anteriorly with the lining of the third ventricle, and backwards with that of the fourth. Embedded in the portion of this layer which floors the canal, near its hinder end, are the large-celled nuclei for the third and fourth nerves; these lie close to the median line—that of the third extending from behind the level of the posterior commissure to the level of the front of the hinder optic lobe; that of the fourth is continuous backwards from this, and consists of larger, greyer cells. External to these, at the hinder end of the latter nucleus, is a cluster of large rounded cells, from which the superior portion of the fibres of the motor root of the fifth nerve arises. Above the aqueduct the grey matter is, as has been seen, continuous into the substance of the hinder optic lobe, only separated therefrom by the fibres from the fillet.

Beneath the grey floor of the aqueduct the upper part of the tegmentum consists of a reticular arrangement of small white, mostly longitudinal, fibres, continued downwards from the subthalamic region to the pons. The uppermost of these are gathered into a definite bundle below the grey sheath of the aqueduct (the **posterior longitudinal fascicle**), which starts in the subthalamic reticular mass and descends, becoming more distinct ultimately (fig.

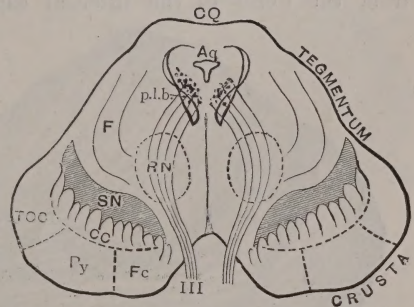


Fig. 792.—Coronal section through the mid-brain—CQ, optic lobes; SN, substantia nigra; Ag, aqueduct of Sylvius; p.l.b., posterior longitudinal bundle; RN, red nucleus; F, fillet or lemniscus; TOC, temporo-occipital part of the crusta; Py, pyramidal tracts; Fc., fronto-cerebellar tract; CC, fibres from caudate nucleus to cerebellum.

791, p.l.b.). This band appears in section below the hinder part of the aqueduct as a flattened triangular bundle; below and external to this is a larger, but less distinct, longitudinal series of fibres, the **superior cerebellar peduncle**, consisting of fibres descending from the inferior part of the thalamus, and through the hinder part of the internal capsule from the frontal cortex. These form a mass, crescentic in section, and include within them the rounded **red nucleus**, and, having on a lower level decussated completely with their fellows of the opposite side, they descend to the cerebellum.

The rest of the tegmentum consists of a **formatio reticularis** continuous above with the reticular formation of the subthalamic region and below with that of the pons. Below this reticulated area and lying on the substantia nigra is a flattish lamina of white fibres, the **fillet**, which appear on the surface at the outer side of the optic lobes, as a fasciculated band of oblique fibres, which stretch from this inwards to the median raphe, where they appear on the surface above the exit of the third nerve. These inner fibres are lost above on the inner side of the subthalamic region in the floor of the third ventricle. The outer part consists of two sections—an upper fillet, which is traceable downwards from

the anterior optic lobe, and a lower fillet from the posterior optic lobe; both these, coalescing, pass through the pons, and, sending a fascicle to the layer between the olives, are continued into the hinder part of the lateral column of the spinal cord.

The arcuated fibres, which are seen in the formatio reticularis in sections of the tegmentum, are partly decussating fibres of the superior cerebellar peduncle, partly arcuated fibres of the fillet, and partly special transverse fibres, passing from the red tegmental nucleus, which can be seen in coronal sections as a ganglionic mass beneath the nates, and having the fillet-layer outside and beneath it for almost the whole breadth of the crus.

It is possible that the fibres of the under fillet may be the continuation upwards of the hinder columns of the medulla, and as these ascending fibres have already decussated in the spinal marrow they do not decussate in the medulla oblongata or mid-brain. The fibres of the posterior commissure pass from the fillet to the formatio reticularis of the opposite tegmentum, and they connect the oculo-motor nuclei.

The crusta consists of three parts—a medial portion, continuous downwards from the fibres of the internal capsule, which arise from the frontal and

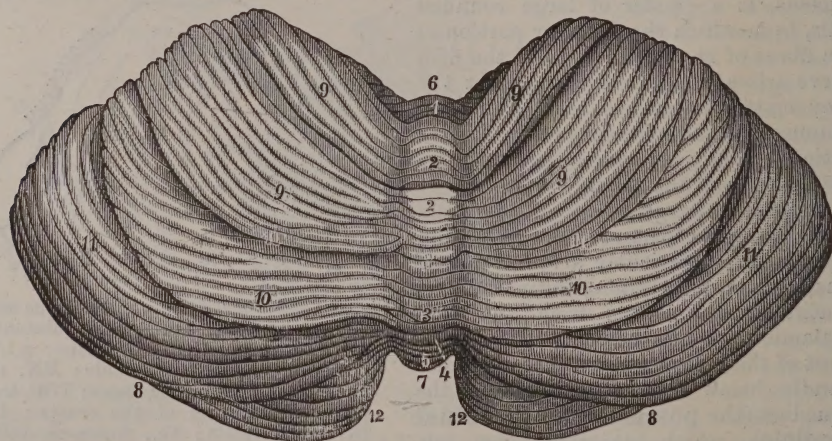


Fig. 793.—Upper surface of cerebellum—1, lingueta laminosa or lingula; 2, lobus centralis with (9) its alae; 3, declive; 4, folium cacuminis; 5, superior semilunar lobe; 6, anterior notch; 7, posterior notch; 8, marginal fissure; 9, lobus quadratus; 10, lobus lunatus posterior; 11, superior semilunar lobe; 12, inner edge of lobus semilunaris inferior.

opercular lobes, and traceable to the pyramid of the medulla; an external of fibres from the occipito-temporal lobe to the formatio reticularis of the pons, consisting of the part which lies directly below the exit of the third nerve, whose fibres pass from the frontal lobes to the cerebellum through the superior peduncles, together with some which pass to the nuclei of the pons. The small bundles of white fibres which directly underlie the locus niger forming the stratum intermedium pass from the caudate nucleus to the cerebellum.

The **locus niger** consists of deeply pigmented and finely-processed nerve cells in many strata. They are not directly related to any of the great ganglionic chains of grey matter either above or below, and have been supposed by Gaskell to be the degenerate cells of the centre which originally supplied the apparatus of the archaic mouth, corresponding to the stomato-gastric ganglia of Arthropods.

545. THE CEREBELLUM is the widened and thickened roof of part of the

posterior cerebral vesicle, and consists of one median and two lateral lobes. Its surface is grey, and closely convoluted into nearly concentric lamellæ, which are separated by sulci so deep that the superficial area bears but a small proportion to the entire surface of grey matter. Its interior is white, and in section presents the branching appearance known as the *arbor vitæ*. The median lobe above and below is known as the superior and inferior vermis.

Each hemisphere has its upper and lower surfaces separated by a **horizontal fissure**, the morphological boundary between the median and the lateral lobes: this widens towards the pons, where it receives the *crus cerebelli*. The upper surface, which wholly consists of the widely expanded upper surface of the middle lobe, is continuously lamellated from side to side, and rises gradually into a median ridge, the **superior vermis**. In front it presents a median notch into which the optic lobes are received; here the surface is turned inwards to overlap the superior peduncle of the cerebellum and valve of Vieussens. There is a still deeper median notch behind, into which the *falx cerebelli* (p. 531) and inferior internal occipital crest project. The upper surface underlies the tentorium, and slopes gently backwards and outwards.

The lateral lobes of the cerebellum bulge as two lateral swellings below, separated by the **valley** in which the inferior vermis lies hidden until the lateral lobes are drawn asunder. The lateral lobes are thick medially on each side of the valley, and become thin towards their outer margin. The groups of lamellæ on their surface are separated by fissures of differing depths, the deepest of which divide the surface into lobules.

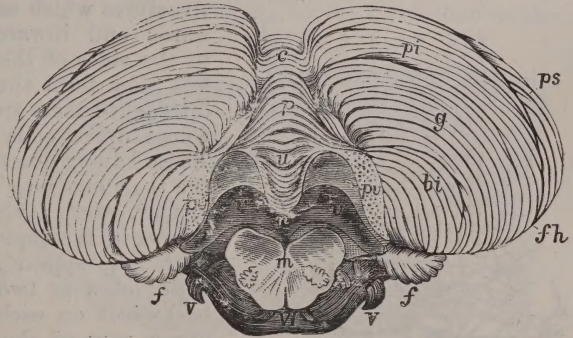


Fig. 794.—Lower surface of cerebellum seen from behind—*pv*, the cut surface where the tonsillitic lobes have been cut off; *c*, tuber valvulæ; *p*, pyramid; *u*, uvula; *n*, nodulus; these four form the inferior vermis; *ps*, posterior semilunar lobe; *pi*, posterior inferior lobe; *g*, lobulus gracilis; *bi*, digastric lobe; *fh*, horizontal lobe; *f*, flocculus; *V*, cavity of fourth ventricle extending on each side into a lateral recess; *V*, *VI*, fifth and sixth nerves.

Of these lobules there are five on each lateral lobe—(1) a **marginal lobule** (*lob. semilunaris inferior*), of about nine lamellæ; (2) **lobulus gracilis**, of about eight lamellæ; (3) a large irregular **cuneiform** or **digastric lobule**, divisible into two or three parts, and consisting of about ten lamellæ; (4) a **tonsillitic lobe**, a rounded prominent swelling on each side of the valley, made up of about six lamellæ.

On the upper surface the median lobe presents four subdivisions—(1) the **central lobule** is placed at the front part of the vermis, is wide medially, consisting of about eight lamellæ, but extends laterally into two thin alæ, which shade away toward the margin; (2) beneath this and over the valve of Vieussens is a transversely lamellose lobule, flattened on the valve, the **lingula**, into which small ridges, the **frænula lingulæ**, extend from the *crus cerebelli*.

(3) Behind the lobulus centralis, the largest part of the projecting ridge of the superior vermis constitutes the **monticulus cerebelli**, which is divided into an anterior part or *culmen* and a hinder or *declive*. These are continuous laterally into a **quadrilateral lobule** similarly divided into fore and hind parts, the *anterior* and *posterior lunated lobules*; (4) the hinder margin of the

upper surface on each side is the **superior semilunar lobule**, which forms the upper lip of the marginal fissure, and these of each side are joined together by a thin median band, the **folium cacuminis**.

The **inferior vermis**, shown by divaricating, still better, by removing, the tonsilic lobules, is divisible from behind forwards into three lobules, the **pyramid**, **uvula**, and **nodulus**.

A thin, white lamella, the **posterior medullary velum**, extends forwards from the front and sides of the nodulus, and gradually thins as it becomes more removed from the cerebellum, finally becoming reduced to a delicate layer of ependyma covered by pia mater, which closes in the fourth ventricle below and behind (fig. 794). The white matter in this fold ends in a concave edge directed downwards and forwards, and stretches on each side into a white footstalk, to which is attached an additional lobule, the **flocculus**, which lies on the outer side of the crus cerebelli (*ib.*, *f*).

The cerebellum is joined to the rest of the brain by the following bands:—

- (1) **crus cerebelli** or middle peduncle, the largest of these uniting structures which consists of fibres passing forwards and inwards from each hemisphere to the sides of the pons of whose lower surface they form the chief part (fig. 780); (2) internal to these are the **superior peduncles** whose upper ends have been already traced. These having descended from the lower part of the thalamus into the tegmentum of the crus cerebri, and having decussated with their fellows in the raphé below the Sylvian aqueduct, here appear at the back of the hinder optic lobes as two rounded ridges traceable backwards on each side of the anterior and upper part of the fourth ventricle to enter the cerebellum (*ib.*; crus cerebelli ad medullam oblongatam). These are united by a thin white layer, the valve of Vieussens, in which the fibres of the fourth nerve, coming from the nucleus on the floor of the aqueduct (fig. 789, Ntr), cross from side to side, and out of which they laterally emerge (fig. 800, *d*). The valve of Vieussens is tied to the space between the hinder optic lobes by the frænulum and is overlapped by

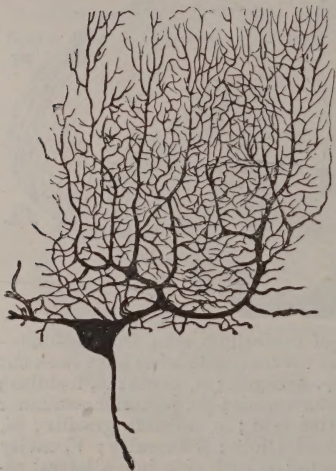


Fig. 795.—A cell of Purkinje from the cortex of the cerebellum, $\times 120$.

the lingula; (3) the **inferior cerebellar peduncles** are the restiform bodies of the medulla oblongata (fig. 799).

The cortex cerebelli consists of four layers—(1) an external layer of connective and vascular processes from the pia mater and neuroglia; (2) a thick layer of radiating branched fibres embedded in a molecular groundwork. The fibres are derived from the processes of (3) the large cells of Purkinje (2.5μ) which form here a layer embedded in a matrix (fig. 795). Each of these flask-like cells sends off one process outwards which branches in a complex manner, its filaments pass at first to the surface, ultimately turning inwards towards the white fibres. The cells of Purkinje are most closely set on the borders of the ridges. From the inner or deep surface of each cell there passes an unbranched axis-cylinder process into and through the next layer into the white medullary part; (4) a granular layer of small, closely set elements ($.7\mu$), probably minute nerve cells, some of which are connected with medullated fibres, and others with a support-reticulum. These granules are in clusters in the deep layers, condensed into a deep stratum towards and around the cells of Purkinje. The

white matter within the cerebellum presents in section a foliated appearance, and hence in section is called the **arbor vitæ** (figs. 778, 796).

In the centre of the white mass of each lateral lobe is a large grey nucleus, the **nucleus dentatus** (fig. 796, *n.d.*), below the fundus of the fissures. This consists of a much corrugated, grey lamella, surrounding, except in front and internally, a whiter central mass. In any plane of section it presents the appearance of a wavy line of yellowish grey matter, enclosing a white central mass.

Around this nucleus the fibres make a densely felted decussating mass. On the inner side of the dentate nucleus and close to the median line on either side of the roof of the fourth ventricle is a second nucleus, the **nucleus fastigii**, separated from its fellow by a narrow median plane of white fibres.

Between the dentate and the roof nucleus are two smaller grey masses, one a narrow club-shaped streak close to the inner side of the dentate nucleus (the **nucleus emboliformis**), and the other, smaller and intermediate, between this and the roof nucleus, the **nucleus globosus** (fig. 797).

The fibres which pass from the medulla oblongata to the cerebellum in the restiform body, cross and radiate in the vermis superior, and enter the labyrinthine network around the nucleus dentatus.

The fibres of the crus cerebelli mostly pass to the hilum of the nucleus dentatus where they are joined by others from the hemispheres and from the **reticulum** around the nucleus dentatus. It is not quite plain whether the fibres of this network join the ganglion cells of the dentate nucleus. There are also commissural fibres from part to part in the cerebellum. The fibres of the superior peduncle come from the lower part of the cerebellum and the dentate nucleus.



Fig. 796.—Sagittal section of lateral lobe of cerebellum, showing the lateral arbor vitæ—*n.d.*, dentate nucleus; *b*, fissure between the anterior and posterior lunate lobes; 1, lamella of tonsillitic lobe; 2, of digastric lobe; 3, of gracilis; 4, of semilunaris; 5, of superior semilunar; 6, 7, 8, of posterior lunate; 9, 10, 11, 12, of anterior lunate; 13, of ala centralis.

546. THE PONS VAROLII appears superficially as a sharply-marked portion of the brain (fig. 790) lying on the clivus above the medulla oblongata, and marked medio-ventrally by a groove for the basilar artery. Laterally the crura cerebelli pass backwards and outwards from it into the cerebellum with no line of demarcation, posteriorly it ends abruptly at the medulla oblongata, anteriorly at the crura cerebri. The line where the crura cerebelli end in the pons is indicated by a line joining the exits of the fifth, seventh, and eighth nerves.

The surface of the pons is transversely grooved as it consists of transverse fibres passing from the crus cerebelli, the foremost of these are arched backwards, and so surround and cover the hinder ones. The upper and back surface of the pons forms part of the floor of the fourth ventricle (fig. 786).

The pons consists of several strata of fibres transverse and longitudinal. The transverse fibres (fig. 791, *s.t.f.*) are arranged in a superficial and a deeper series (*ib.*, *d.t.f.*), they pass from the crus cerebelli to the crus cerebri. At the median raphe the fibres coming from the opposite crura cerebelli meet and

interlace, here dipping deeply into the substance of the [pons] and turning forwards into the crus cerebelli of the opposite side; on each side of these upturning fibres and under the transverse layer is a longitudinal set of fibres passing from the crista of the crus cerebri to the corpus pyramidale (*ib.*, *Py*), and these intervene between the superficial and the deep fibres from the crus cerebelli. The longitudinal pyramidal fibres are crossed, not only by the transverse fibres but by layers of grey matter on each side, making up the **nucleus pontis**, and conspicuous in transverse sections. From these arise fibres which join the pyramidal tract upwards as they go to the hemispheres; other fibres pass hence to the cortex cerebelli.

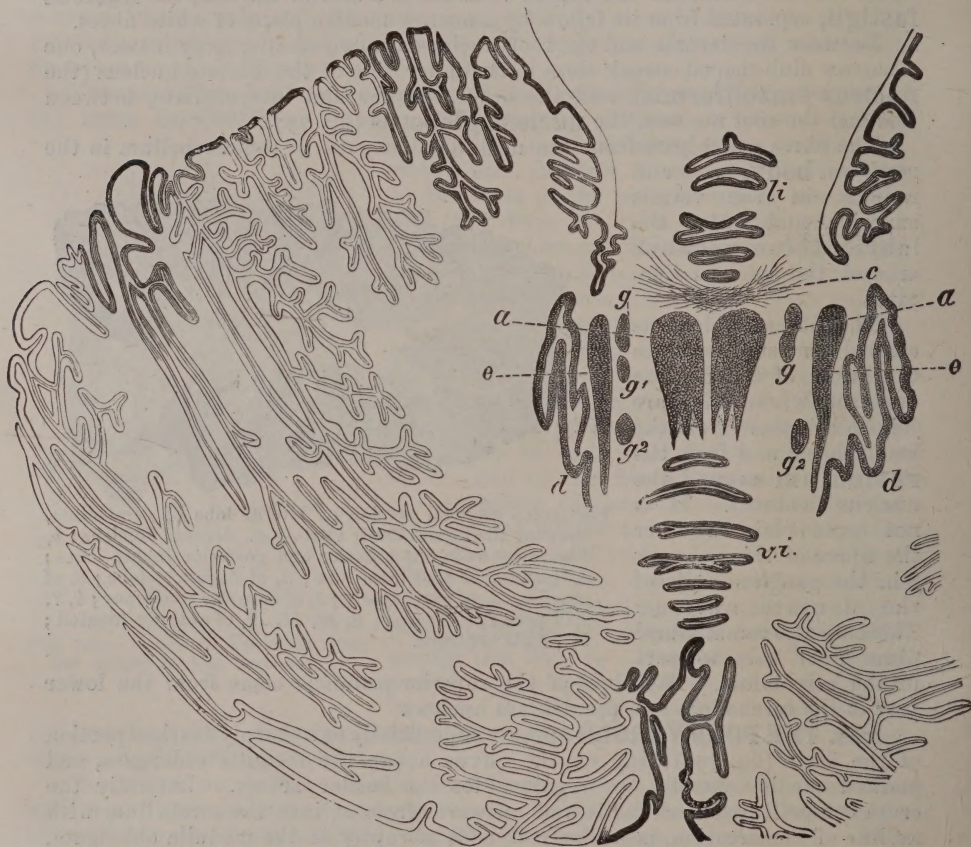


Fig. 797.—Horizontal section of the white centre of cerebellum, $\times 2$ —*a*, corpus dentatum; *li*, lingula laminosa; *a*, nucleus fastigii; *g*, nucleus globosus; *e*, nucleus emboliformis; *c*, decussating fibres; *v.i.*, inferior vermis.

The upper or dorsal part of the pons consists of a continuation of the formatio reticularis from the tegmentum and floor of the Sylvian aqueduct downwards to the medulla. This is covered towards the floor of the fourth ventricle with a layer of grey matter, in which are the grey nuclei of several cerebral nerves which will be better seen in the dissection of the fourth ventricle. There is here a median decussation in the fibres of the reticular formation.

As the pons approaches the medulla a grey mass appears in the reticular part, the **upper olive** (fig. 798, *o.s.*).

As the crus cerebelli is directed backwards at the upper part of the pons to unite with its ventral layer, a portion of the reticular formation comes to the surface ventrally between the crus cerebelli and the crus cerebri. The front of the pons is more closely connected with the mid-brain than with the hind-brain.

While the transverse commissural cerebellar fibres sharply mark off the pons from the medulla on the anterior surface, there is no such line of demarcation on the posterior or fourth-ventricle side.

The **fourth ventricle** is the modified cavity of the hinder cerebral vesicle, and is exposed by dividing the vermis of the cerebellum medially and reflecting

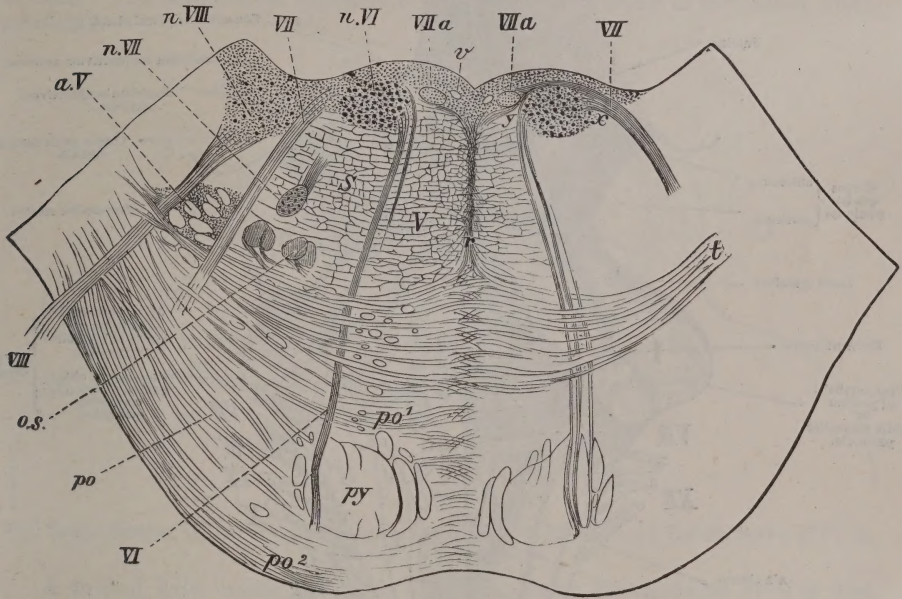


Fig. 798.—Section across the pons Varolii, opposite the middle of the fourth ventricle—*v*, superficial vein below floor of ventricle; *VIIa*, intermediate part of facial nerve; *n. VI*, nucleus of sixth nerve; *VII*, seventh nerve; *n. VIII*, superior nucleus of auditory nerve; *n. VII*, nucleus of intermediate part of seventh nerve; *a. V*, ascending root of fifth, enclosed in substantia gelatinosa; *os*, superior olivary nucleus; *po*, intercerebellar fibres of pons, enclosing grey matter in its meshes; *VI*, sixth nerve; *py*, pyramid bundles.

its halves to either side. Its floor appears rhomboidal (fig. 799) and its axis is vertical. For the lower half the restiform bodies form its lateral margin, for the upper half the superior cerebellar peduncles. Medially its floor is marked by a sulcus which begins below in a pit, the ventricle of Aranzi, and ends above at the aqueduct of Sylvius. The broadest part of the ventricle is at the level where the restiform bodies of the medulla oblongata pass into the cerebellum, from whence it narrows forward between the two superior cerebellar peduncles. Its sagittal diameter varies very much, being shallow for its lower half, much deeper above where the cerebellum is excavated; in front of this the valve of Vieussens roofs it in.

The floor or anterior wall is formed partly of the upper part of the medulla, but mostly by the pons. On each side of the median groove is the **eminentia**

teres, beginning at the apex of the space and expanding a little forwards. This consists of fibres descending from the formatio reticularis of the tegmentum of the crus cerebri on their way to pass behind the olives and the arcuate fibres to the lateral tract of the cord. These are crossed transversely at the widest part of the cavity by white *striae acustice* passing from the middle groove outwards, conspicuous against the grey background of the lining of the cavity and continued outwards into the eighth nerve (fig. 799, *VIII*). Behind these and external to the fasciculus teres is a triangular dark grey *ala cinerea*

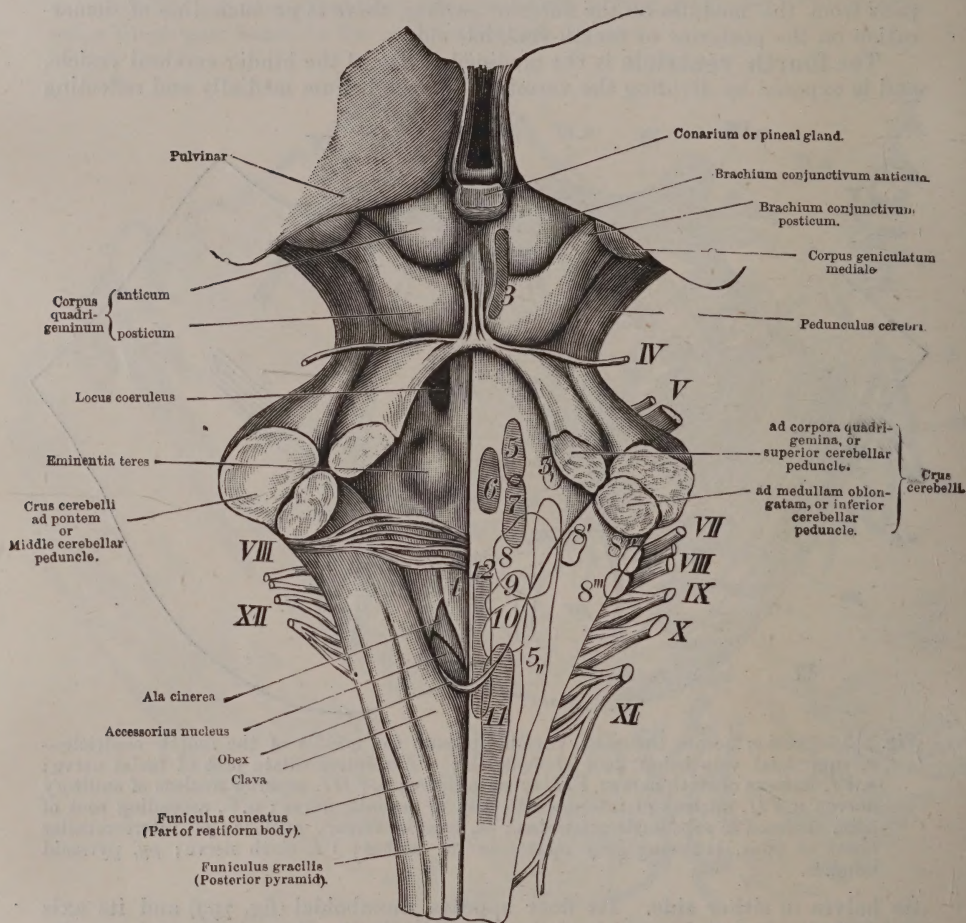


Fig. 799.—Diagram of the fourth ventricle. Its floor is shown on the left side; on the right the relative situations of the nuclei of the several cranial nerves are indicated.

on each side, pointed in front and depressed behind into the *fovea posterior*. To the area where these converge to the central groove the name *calamus scriptorius* is given. In front of the striae and external to the eminentia teres is a second depression, the *locus coeruleus*, from which a reddish streak, the *substantia ferruginea*, extends to the beginning of the aqueduct of Sylvius.

The roof of the fourth ventricle consists anteriorly of the valve of Vieussens; covered by the lingula of the cerebellum, behind which is a vascular layer continuous laterally into the pia mater, clothing the medulla oblongata, and

forwards into that of the cerebellum. This on its inner surface has an epithelial coating with no nerve elements, but is continuous laterally where it touches the sides of the medulla oblongata, into structures which remain adherent to the medullary edges of the ventricle. These structures are very variable, and are (1) the *obex*, a triangular medullary lamella uniting the diverging ends of the *clavae*; (2) *ponticulus*, a seam continued up from the obex, ending internally; (3) the *ligula*, a continuation of the ponticulus around the outer part of the restiform body here bounding the ventricle.

The rest of the covering is the posterior medullary velum, which is pierced by the oval **foramen of Magendie**, allowing the ventricle to communicate with the subarachnoid space. On the under side of this is the choroid plexus of the fourth ventricle, which extends from the foramen of Magendie to the inferior vermis. The foramen of Magendie is probably secondary in formation, often artificial.

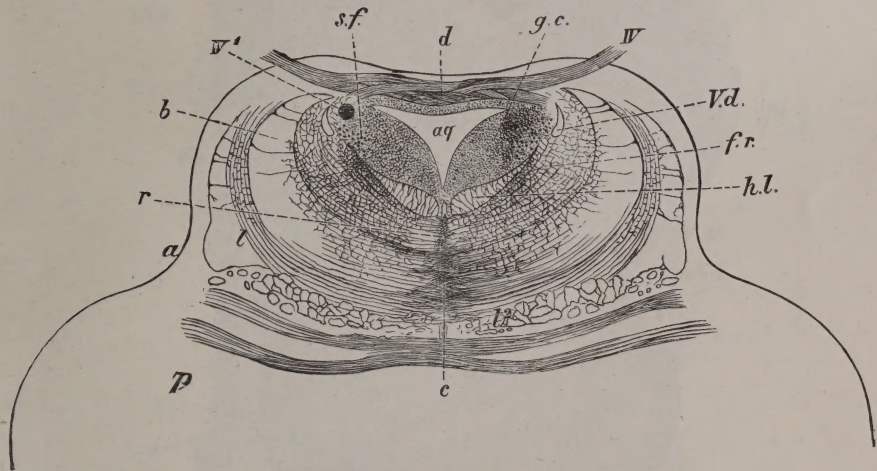


Fig. 800.—Section across Sylvian aqueduct (*aq*)—*d*, decussation of fourth nerve (*IV*) in the valve of Vieussens.

A lateral hole under the ligula may also exist, the foramen of Key and Retzius or Mierzejewsky.

The **restiform bodies** of the medulla can now be seen, one on each side of the fourth ventricle. They form the largest of the superficial constituents of the cord, and their surfaces appear compound. For the lower third the back of the medulla is divided into two parts by the posterior median fissure, continued downwards into the posterior median septum of the cord (fig. 802). On each side of this fissure there is a slender band, the *clava*, thickening above as it diverges from its fellow at each side of the fourth ventricle, and narrowing as it descends towards the spinal cord, this lower end is the funiculus gracilis. External to these are two similar columns, the columns of Burdach, or the **cuneate columns**, which are continued downwards into the posterior lateral columns of the spinal cord: each of these dilates at the side of the fourth ventricle into the cuneate tubercle specially marked in young brains. Still farther outward is an obscure and narrow white ridge, the **column of Rolando**, which suddenly expands above the column of Burdach into the grey tubercle of Rolando directly below the acoustic striæ. This forms the hinder boundary of the posterior lateral groove. These parts of the restiform body collectively form the side boundaries of the fourth ventricle behind, and turning upwards they, for the most part, pass into the cerebellum.

The medulla oblongata exhibits in section white and grey matter arranged in certain definite masses. The **pyramids** consist of white motor fibres descending from the crusta of the pons, and consist chiefly of two sets of fibres, the larger set (90 per cent.) of these which form most of the surface fibres of the pyramid are medial, and these decussate below at the apex of the

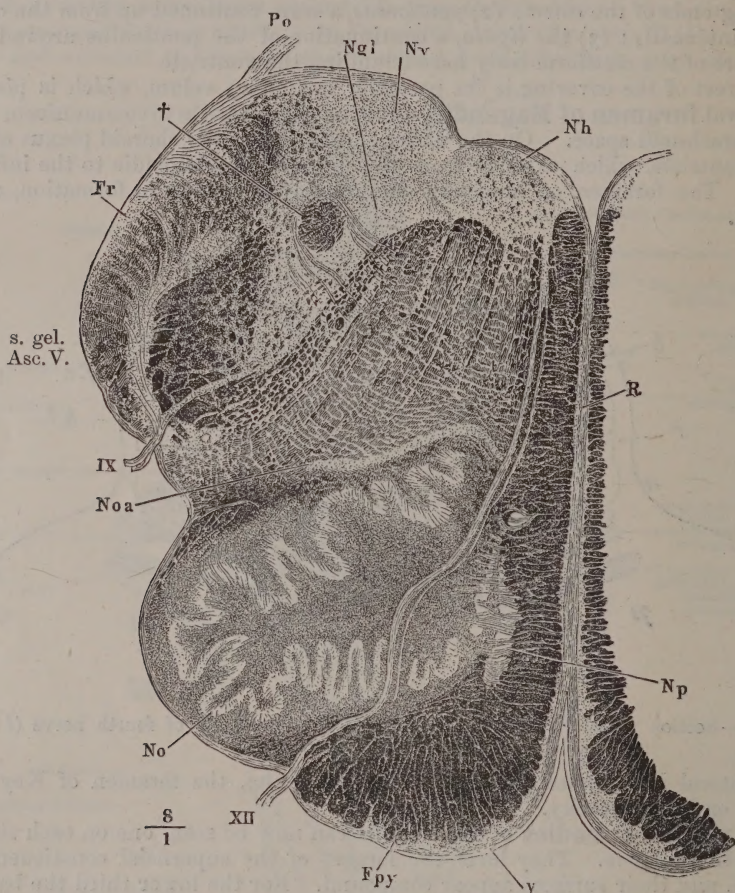


Fig. 801.—Section of the medulla oblongata through the olivary body—XII, hypoglossal nerve; Nh, nucleus hypoglossi, with, at its inner part, the nucleus of the fasciculus teres represented of a lighter colour; Nv, nucleus of vagus, with, beneath it (Ngl), the nucleus of the glossopharyngeal nerve; Po, ponticulus; †, funiculus solitarius, or the round bundle; Fr, funiculus restiformis, containing the nucleus gracilis above the line and the nucleus of the cuneate fascicle below it; IX, glossopharyngeal nerve root above, and (s. gel.) substantia gelatinosa, internal to which, and vertically under Po, is the nucleus ambiguus; Asc. V., ascending root of fifth nerve; Noa, nucleus of external parolivary body, the line crosses the nucleus of lateral column; No, nucleus olivæ; Np, internal parolivary body; Fpy, pyramid; y, arciform fibres overlying it; R, raphé.

pyramid, and passing through the grey anterior cornu enter and form the lateral tract of the spinal cord below; these constitute the crossed pyramidal tract. The outer set consist of those bundles which pass into the anterior column of the cord without crossing, and they form the outer part of the pyramid or the direct pyramidal tract: these, when traced upwards, ascend

behind the crossed fibres and there are lost. Other fibres from the anterior column dip deeply into the formatio reticularis of the medulla.

Between the pyramid and the grey floor of the central canal there is a second decussation of fibres, which pass forwards from the hinder part of the medulla oblongata, and thence to the pyramid. These constitute the **sensory pyramid-crossing**. These fibres come chiefly from the fasciculi cuneati, and after crossing they assume a longitudinal, but by no means easily traced course. They are more or less arcuated on the side of the fourth ventricle, and ascend

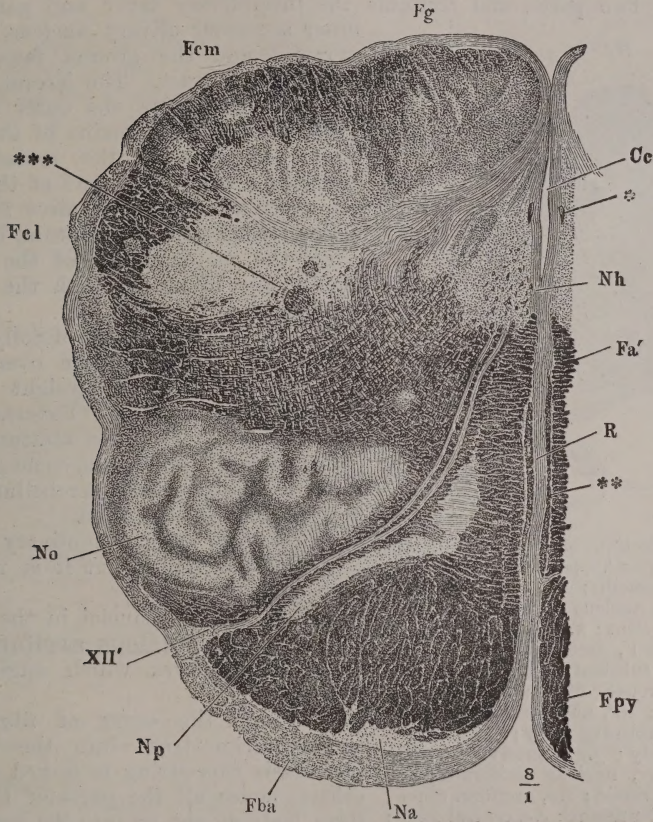


Fig. 802.—Section of the medulla oblongata through the lowest point of the olivary body—Fg, funiculus gracilis; Fcm, inner cuneate funicle; Fcl, lateral cuneate funicle; ***, nerve cord funiculus solitarius; No, olivary nucleus; XII', root of hypoglossal nerve; Np, pyramidal nucleus; Fba, arciform fibres; Fpy, pyramid; **, blood-vessels in raphé R; Fa', remains of anterior column; Nh, hypoglossus nucleus; Cc, central canal.

outside the raphé behind the pyramid and internal to the olive, and, hence, are called the **olivary intermediate tract**. Each longitudinal band interlaces with other longitudinal bands continued upwards from the anterior uncrossed tract, and with these form the lateral tract.

Outside the olivary intermediate tract crossed fibres ascend longitudinally among the scattered masses of grey matter, forming the lowest part of the formatio reticularis of the medulla. A similar reticular formation extends as a long continuous tract beyond the upper decussation.

Besides the superficial arcuated fibres which ascend from the fasciculi

cuneati, there are also similar deeper arcuated fibres which traverse all parts of the medulla except the pyramids. The most superficial of these join the superficial arcuated fibres by piercing through or beside the olive, and with the deeper arcuated fibres pass into the restiform body externally; internally they decussate in the raphé and pass into the restiform bodies. The internal deep arcuated fibres are supposed to become longitudinal.

The hypoglossal fibres form a boundary between the median and the lateral segment of the medulla oblongata; the median is divided by the raphé into two parts, and contains the interolivary layer and part of the inner accessory olivary nucleus, also the pyramid and the ground fasciculus of the anterior tract. The lateral contains the olivary nucleus, the outer accessory nucleus, also the remains of the lateral tract, and part of the crossed inner arcuated fibres. The part of the formatio reticularis over the olive forms the motor tract of the tegmentum, by whose fibres the motor nuclei of the cerebral nerves are connected with the cerebral hemispheres.

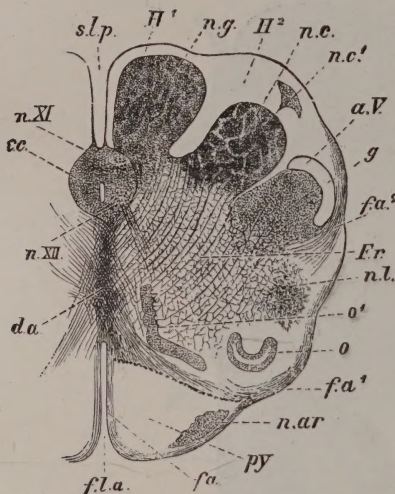


Fig. 803.—Section of the medulla oblongata, $\times 4$ —*s.l.p.*, posterior fissure; *H¹*, funiculus gracilis; *H²*, funiculus cuneatus; *n.g.*, nucleus of the clava; *n.c.*, cuneate nucleus; *n.c¹*, external cuneate nucleus; *a.V*, ascending root of fifth nerve; *g*, substantia gelatinosa; *f.a²*, external arcuate fibres; *Fr*, formatio reticularis; *n.l*, nucleus lateralis; *o¹*, median parolivary body; *o*, nucleus of olivary body; *f.a¹*, anterior arcuate fibres; *n.ar*, nucleus arciformis; *py*, anterior pyramid; *f.a*, arciform fibres; *f.l.a*, anterior fissure; *c.c*, central canal; *n.XI*, nucleus of the spinal accessory nerve; *n.XII*, hypoglossal nucleus; *d.a*, anterior decussation of the pyramids.

the olive and from the spinal cord with the direct cerebellar tracts, sending these partly into the lateral column of the cord. The lateral column has contributed one part to the restiform body, the direct cerebellar tract, and one larger element to the pyramid, and between these the olive is interjected.

The medulla oblongata is traversed by a central canal below, which expands into the fourth ventricle above. Its exterior is of white substance, but within it grey masses are disposed symmetrically on each side, underlying the peripheral white matter, thus a grey column, the *nucleus gracilis*, lies on the funiculus gracilis and clava, increasing as it ascends and forming above the clavate nucleus. External is the nucleus cuneatus, at first small but enlarging upwards; still farther outwards is the grey mass of the posterior cornu, in front

The **arcuated fibres** of Solly pass towards the median fissure over to the pyramid, forming, as straight fibres a constituent of the raphé. Externally they are connected with the stratum zonale of the medulla oblongata, some go by the funiculus gracilis to the cerebellum, others are connected to the olive.

The fibres from the olivary nucleus cross in the raphé, but it is uncertain whither.

There are grey nuclei in the stratum zonale, a grey **nucleus arciformis** lies beneath the fibres which engirdle the pyramid.

Through the entry of fibres from the posterior tract into the formatio reticularis this string is linked with the others, hence all the parts of the restiform body do not go into the cerebellum. The restiform is a new and temporary combination of fibres uniting the arcuated fibres, such as come from the vicinity of

of which is the grey mass of the anterior cornu. These grey masses in the restiform body are not prolonged into the cerebellum, but the head of this cornu becomes cut off from the base by the passage through it of the fibres of the lateral cord to the decussation, a little above which it becomes lost. This forms, above, the median segment of the grey floor of the fourth ventricle.

Besides these there are (1) the **olivary nucleus**, composed, like the dentate nucleus of the cerebellum, to which it is connected by several strands of fibres, of a wavy layer of brownish grey matter around a nucleus of white, with a hilum on the inner and posterior side, through which fibres enter from the posterior column of the cord of the opposite side, which are partly lost in the grey wall, partly traverse it to the cerebellum. On section this appears like a corrugated brown line.

(2) **Accessory olivary nuclei** are small, rod-like, flattish grey masses lying parallel to the side of the olive, appearing in section as bands of grey matter.

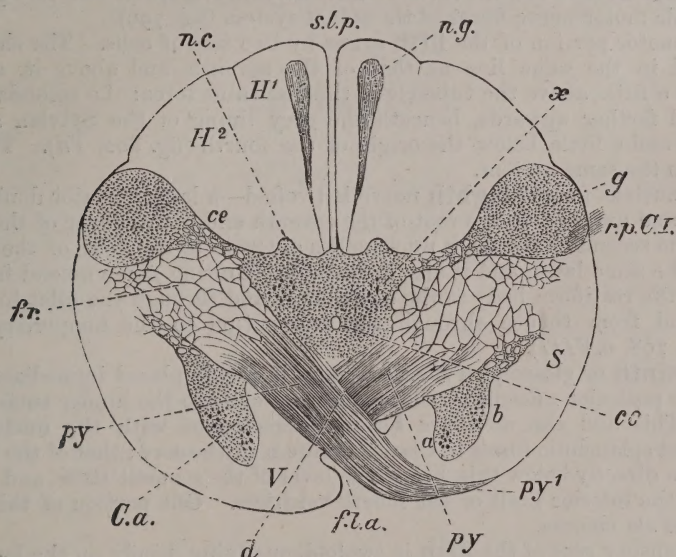


Fig. 804.—Horizontal section of the medulla oblongata at the decussation of the pyramids—*f.l.a.*, anterior fissure; *d*, decussating fibres displacing the anterior fissure; *C.a.*, anterior horn; *V*, anterior column of grey matter; *f.r.*, formatio reticularis; *a, b*, nerve-cells; *c.c.*, central canal; *c.e.*, neck of hinder cornu; *S*, lateral column; *g*, head of posterior horn; *r.p.C.I.*, posterior root of 1st cervical nerve; *n.c.*, beginning of the nucleus cuneatus; *n.g.*, clava of the nucleus gracilis; *H¹*, funiculus gracilis; *H²*, fasciculus cuneatus; *s.l.p.*, posterior median fissure; *x*, groups of cells in base of posterior cornu.

One of these is the **internal parolivary nucleus**, and is internal and in front of the olive, near the centre of the medulla and below the pyramid. At first it is simple, but above it becomes bent inwards and forwards.

The **lateral accessory nucleus** lies behind and external to the olive, from which it is separated by the roots of the hypoglossal nerve. These nuclei are formed of gelatinous matter, with many small yellowish multipolar cells, each with one axis-cylinder process, but not forming a continuous layer.

Besides these concrete nuclei there are many indefinite masses of grey matter scattered among the white fibres in different directions.

Beneath the lining of the floor of the fourth ventricle are the group of nuclei from which arise the most of the cranial nerves. That for the **sixth** is a long narrow cluster of large cells beneath the anterior portion of the fasciculus

teres and close to the median line. Its centre is in the same line as that for the third and fourth above, and is also on the line of the anterior horns of grey matter of the spinal cord below. These nerves are therefore serial homologues of the anterior or efferent roots of spinal nerves. Farther back in the same line is the nucleus of the **twelfth** pair, whose anterior extremity is on the level of the acoustic striæ; its posterior extends to the lowest level of the ventricle of Aranzi. The nucleus of the **seventh** or facial nerve is external and a little below that of the sixth, extending from the level of the acoustic striæ upwards to the level of the hinder border of the most prominent part of the fasciculus teres. This origin is on the same horizon as the large-celled portion of the lateral horn of the cervical spinal cord. The nucleus for the **spinal accessory** nerve (eleventh pair) is on the same line, and extends from the level of the top of the calamus scriptorius down into the last-named region of the spinal cord. These two nerves are therefore homologues of the non-gangliated splanchnic motor nerve fibres of the spinal system (fig. 799).

The motor portion of the **fifth** arises by two sets of cells. The chief centre is placed in the same line as that of the seventh, and above it, extending upwards a little above the tubercle of the fasciculus teres; the secondary centre is placed farther upwards, beneath the grey lining of the Sylvian aqueduct, external and a little below the origin of the fourth (fig. 800, *Vd*). These also belong to the same system.

The nucleus for the **eighth** nerve is twofold—a large anterior double centre beneath and external to the root of the seventh and under cover of the acoustic striæ; the second or posterior nucleus lies external to the floor of the ventricle and on the same level, and it also is twofold. Uniting fibres ascend from these through the restiform body to the cerebellum, and through the fillet to the optic lobes, and from thence through the tegmentum to the temporo-sphenoidal lobe (fig. 798, *n. VIII*).

The **ninth** or glosso-pharyngeal nucleus is deeply placed immediately below the inner posterior nucleus of the eighth and close to the hinder surface of the olive. This and the next are serially homologous with the nuclei of the gangliated splanchnic fibres in Clarke's column in the cord; that of the **tenth** or vagus lies directly below this, below the level of the acoustic striæ, and stretches as far as the inferior limit of the fourth ventricle. One portion of this nucleus lies in the ala cinerea.

The sensory root of the **fifth** is twofold, one lying deeply on the level of the mid part of the superior cerebellar peduncle in the pons, and one much lower down from the long grey nucleus which extends beneath the column of Burdach. This and the root of the tenth and part of that of the ninth are homologous with the posterior roots of spinal nerves.

The **spinal cord** is the flattish cylindroidal continuation of the medulla oblongata into the vertebral canal, enclosed in the *thea vertebralis* (§ 259), and extending to the level of the lower border of the first lumbar vertebra; here it suddenly narrows to a **conus terminalis**, which tapers to a slender, glistening **filum terminale**, in the centre of the cauda equina, traceable as far as the third sacral vertebra. From each side of the spinal cord arise the 31 pairs of spinal nerves, which leave the vertebral canal through the inter-vertebral foramina (figs. 801, 802).

The dimensions of the cord vary within wide limits in different individuals, but the averages are as follows:—

Male, length, 43 cm.;	volume, 34 ccm.;	weight, 34 grammes.
Female, „ 40 „	„ 30 „	„ 29 „

Motion of the vertebral column does not appreciably affect the level of the end of the cord.

The fetal cord extended originally for the whole length of the spinal canal, but the

vertebral column begins to outgrow it at the tenth week, and by the time of birth the cord only reaches as far as the second lumbar vertebra. The outgoing nerves, which at first passed horizontally outwards to their respective metameres, become more and more oblique and retracted within the theca, owing to this inequality of growth. Not only are the rates of lengthening of the growing cord and of the vertebral column unequal, but the several regions of both grow unequally. Thus between the sixth fetal month and maturity, the region of the cervical nerves on the cord lengthens from 21 mm. to 100 mm., while the cervical canal has grown from 22 mm. to 120 mm. The region of the dorsal nerves has lengthened from 39 mm. to 260, and the dorsal canal from 45 to 300. The portion from which the lumbar nerves arise has extended from 13 mm. to 50 mm., and the lumbar canal from 27 to 190, the sacral-nerve portion has grown from 10 to 36, while the corresponding part of the canal grows from 16 to 140. The female cord is equal to the male in the cervical nerve region; much shorter in the dorsal (260 : 230), longer in the lumbar (56 : 50), but shorter in the sacro-coccygeal nerve region (36 : 30). The female cord more often than the male reaches to the second lumbar vertebra.

The levels of escape from the cord of the various spinal nerves are variable, both as regards their absolute and relative positions, but are usually as shown in the accompanying table.

TABLE OF THE LEVELS OF ORIGIN OF SPINAL NERVES IN TERMS OF VERTEBRAL BODIES AND SPINES.

Level of body of	No. of nerve.	Tip of level of spine of	Level of body of	No. of nerve.	Tip of level of spine of
C. 1 ———	C. 1	...	D. 8 ———	9 ———	7 d.
2 { ———	2	...	9 ———	10 ———	8 d.
3 { ———	3 ———	1 c.	10 ———	11 ———	9 d.
4 ———	4 ———	2 c.	———	12 ———	10 d.
5 ———	5 ———	3 c.	11 ———	L. 1 ———	11 d.
6 ———	6 ———	4 c.	12 { ———	2 ———	...
7 { ———	7 ———	5 c.	———	3 ———	12 d.
8 ———	8 ———	6 c.	———	4 ———	
D. 1 { ———	D. 1 ———	7 c.	———	5 ———	...
2 ———	2 ———	1 d.	———	S. 1 ———	
3 ———	3 ———	...	L. 1 { ———	2 ———	1 L.
4 ———	4 ———	2 d.	———	3 ———	
5 ———	5 ———	3 d.	———	4 ———	
6 ———	6 ———	4 d.	———	5 ———	
7 ———	7 ———	5 d.	———	C. 1 ———	
8 ———	8 ———	6 d.	L. 2	...	...

The cord is contracted where it joins the medulla oblongata, but widens from the second cervical to the first dorsal vertebrae; it again becomes contracted and cylindrical from this point to the eleventh dorsal, where again it dilates, but rapidly narrows at the top of the first lumbar vertebra. The upper is the **brachial enlargement**, the lower the **lumbar enlargement**.

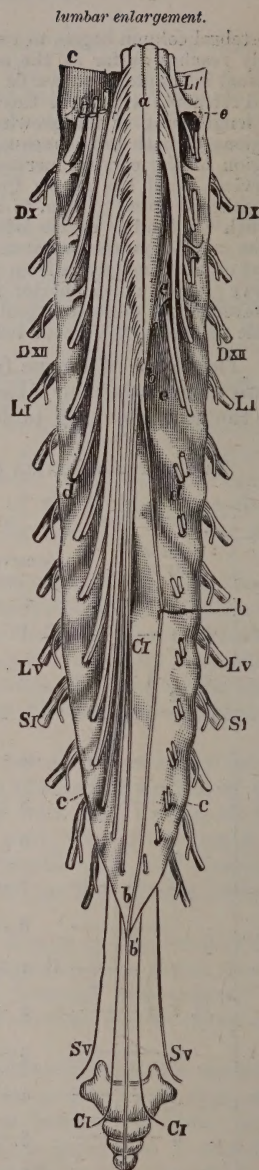
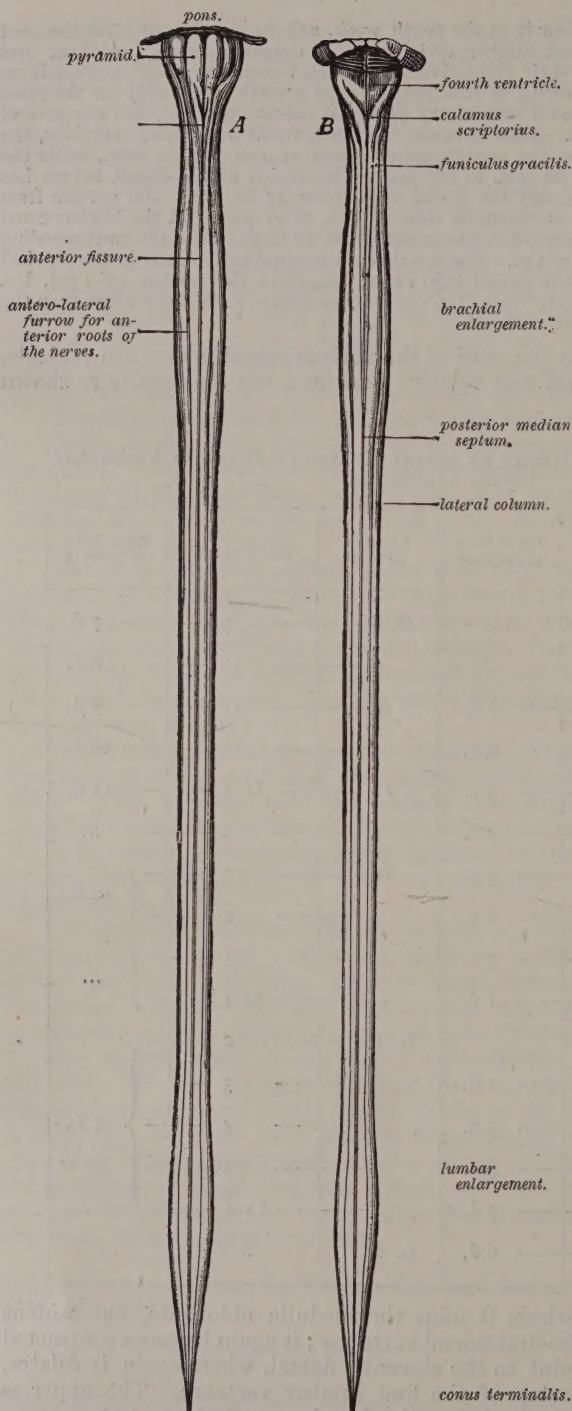


Fig. 805.—Views of the spinal cord and medulla oblongata —A, from before; B, from behind, $\frac{2}{3}$.

Fig. 806.—View of the lower end of the spinal cord and cauda equina, seen from behind by slitting and reflecting the theca, $\frac{2}{3}$ —a, posterior fissure; b, filum terminale within the theca; b', filum prolonged beyond the theca; c, theca, cut border; d, nerve roots cut, showing the separate hole in the theca for each; e, ligamentum denticulatum. The levels of the different nerves are shown.

The membranes of the cord and the naked eye anatomy of the nerve roots have been already noticed (p. 259). The pia mater, which is here firm, is closely adherent to the cord, and sheathes the nerves arising from it.

Along the anterior median line is an **anterior median fissure** dipping in for one-third the thickness of the cord, with margins capable of divarication, and containing in it a fold of pia mater, in which descends the *anterior spinal artery*. The bottom of this fissure consists of white nerve matter, the **anterior** or white **commissure**. This fissure becomes deeper towards the lower end of the cord (fig. 807). The thick glistening pia mater along this fissure is the *linea splendens*.

Posteriorly, in the median line a thin incomplete lamella of the pia mater dips in for half the thickness of the cord; but its surfaces are adherent to the contiguous surfaces of the cord, so this fissure cannot be opened, and hence it is known as the **posterior septum of the cord**. From the posterior spinal arteries which lie in the membranes along this fissure, a series of *posterior septal*

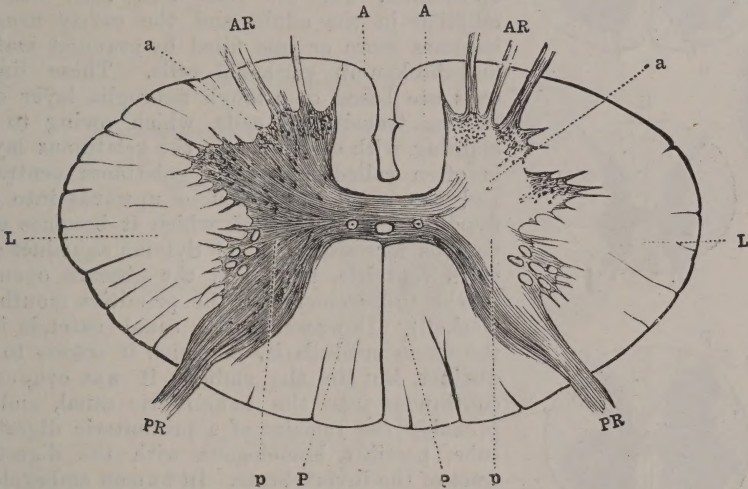


Fig. 807.—Transverse section of spinal cord opposite the eighth cervical vertebra—A A, the white anterior column; L, L, lateral columns; P, P, the posterior columns of white matter; a, anterior horn of grey matter; p, posterior horn; AR, anterior roots; PR, posterior roots.

arteries pass inwards to the grey or **posterior commissure of the cord**, which lies along the bottom of this septum (fig. 813).

Each of the two sides of the cord thus separated presents a longitudinal furrow, along which the posterior roots of the nerves enter the cord. This is called the **lateral groove**, and it divides the side of the cord into two columns, a posterior between it and the posterior septum, and an antero-lateral which consists of the remaining two-thirds of the surface of the cord. This latter is again subdivided by the line, along which the anterior roots of the nerves come out, into an **anterior** and a **lateral column**, but there is no groove nor continuous line on the surface. Between these, rows of small branches from the lateral spinal arteries enter the cord along the anterior and posterior nerve roots (*anterior* and *posterior radicular arteries*). These arteries are very long for all the nerves of the cauda equina.

The posterior column in the cervical region is indented by a longitudinal **intermediate groove**, dividing its surface into two subordinate columns—an inner or posterior-median column (**Goll's column**), and an outer or

posterior-lateral (**Burdach's**). Between these a row of fine arteries pierce into the cord (the *inter-funicular* branches of the posterior spinal arteries—fig. 813).

The surface of the cord consists chiefly of longitudinal white medullated nerve fibres, each enclosed in a sheath of neuro-keratin, but showing no distinct sheath of Schwann. When acted on by osmic acid they exhibit **Lantermann's notches** (p. 52).

The transverse section of the cord presents the following appearances:—(1) In each half there is a somewhat crescentic grey mass centrally, having its

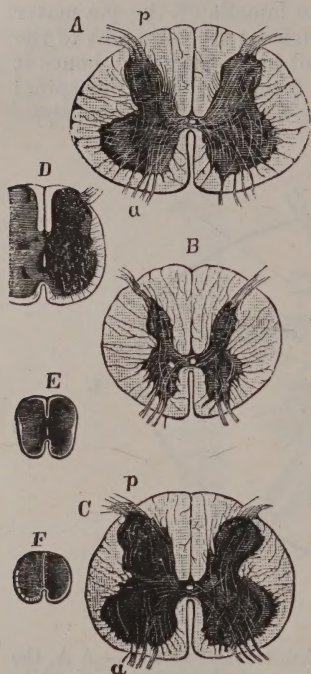


Fig. 808. — Transverse sections of the spinal cord at different levels—A, through the sixth cervical vertebra $\times 2$; B, the third dorsal vertebra $\times 2$; C, at the third lumbar vertebra $\times 2$; D, the upper part of the conus medullaris $\times 3$; E, middle sacral portion of conus medullaris $\times 3$; F, coccygeal portion of conus medullaris $\times 4$.

the grey matter. These horns can be seen in sections made in any part of the cord.

If the cord be cut in the cervical and upper dorsal region, a third or **lateral horn** (*intermedio-lateral tract*) projects outwards opposite the level of the grey commissure. In the cervical region this lies on the ventral side of the coronal median plane, in the dorsal it is behind that plane. If the cord be cut in the dorsal region or in the upper cervical, or at the exit of the lower lumbar nerves, a fourth area of grey matter appears on the inner side of the

convexity directed inwards, and joined to its fellow by the grey commissure; the whole grey central mass has consequently somewhat the figure of a capital letter H. In the middle of the grey commissure there is a minute **central canal**, lined in the fetus by ciliated columnar epithelium, but the cells lose their distinct ciliation in the adult, and the cavity usually becomes more or less filled by granular matter and broken-up epithelial cells. These lining cells are based on a tough neuroglia layer containing transitional cells, which, owing to its staining with carmine, like the gelatinous layer, is often called *substantia gelatinosa centralis*, and the canal is continuous upwards into the fourth ventricle, through which it becomes continuous forwards with the Sylvian aqueduct and third ventricle, to end at the obscure opening in the tuber cinereum (the primitive mouth, of Gaskell). Downwards the canal extends into the conus medullaris, in which it ceases to be distinct, but in the embryo it was originally continuous into the neurenteric canal, and is probably the remains of a protenteric digestive tube, possibly homologous with the digestive tract of the invertebrata. In human embryology this canal is the remains of the cavity lined by the epithelium of the dorsal groove.

The grey matter in each half of the cord presents, on transverse section, four distinct parts. Anteriorly it projects towards the anterior nerve roots and forms the **anterior horn**, a blunt, irregular mass, not reaching the surface; posteriorly it is elongated to the floor of the lateral groove as the **posterior horn**, longer and narrower than the anterior. The section shows that the grey matter narrows to a neck where this horn joins the rest of

neck of the posterior horn and adjoining the hinder side of the grey commissure. This is the **visceral** or **Clarke's vesicular column**.

These grey prominences vary in structure and relative size in the different regions. Although appearing in section as horns it must be remembered that these are columns.

Their sections present characteristic variations in the different parts of the cord as shown in the figures. The anterior horns are wide and short below, narrower medially, and the lateral horns fuse with the anterior above and below. The posterior horn is, for the most part, narrow at the neck, widening backwards and outwards into the *caput cornu*, whose end and sides are surrounded by a so-called gelatinous material, the **substantia gelatinosa**, which extends to the surface where the posterior nerve roots enter, and exhibits a faint streaking of cross lines which radiate from the nerve roots. The hindmost point is called the *apex* of the posterior horn.

The anterior horn contains very large and characteristic multipolar cells, about 120μ , and some smaller but also much branched cells. All these cells

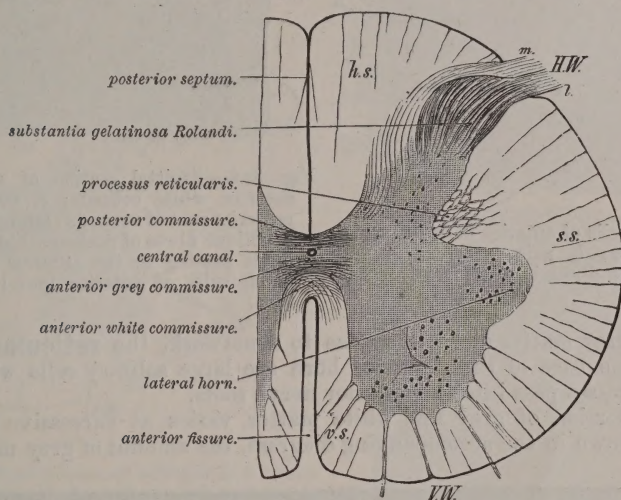


Fig. 809.—Section of the spinal cord through the lumbar enlargement—*v.s.*, anterior column; *s.s.*, lateral column; *h.s.*, posterior column; *H.W.*, posterior roots of the nerves; *V.W.*, anterior roots.

send off branched protoplasm-processes, whose network makes the chief part of the basis of this material, and their axis-cylinder processes pass outwards as the chief constituents of the anterior root of each nerve (fig. 810).

The cells of the anterior horn are usually grouped in clusters—an internal, an anterior, an antero-lateral, and a postero-lateral. The first set diminish in number towards the lower part of the cord, vanishing in the lumbar region; the second and third form one group in the mid-cervical region, the postero-lateral are usually large and distinct.

The cells of the lateral horn are mostly smaller, but give off much-branched processes. Those in the dorsal region are twofold, one series on the ventral side are larger, resembling those of the anterior horn, but the majority are small, diminish in number, and finally vanish in the lower dorsal region. Those of the visceral column are still smaller (40 to 90μ) and present fewer processes. They are usually elongated vertically and their axis-cylinder processes are the small **leucentric fibres** which pass in the anterior roots to the visceral ganglia (p. 58).

The posterior horn cells are, for the most part, very small (18μ) and fusiform, and show fine netted protoplasm processes, but no appreciable axis-cylinder processes. Fine medullated fibres traverse these grey masses in large numbers.

On the outer side of the neck of the hinder horn, behind the lateral horn, there is a network of white fibres in-



Fig. 810.—Large cells of anterior horn—*a*, multipolar nerve-cells; *b*, axis cylinder; *c*, grey matter; *d*, white fibres in transverse section; *e*, cell processes.

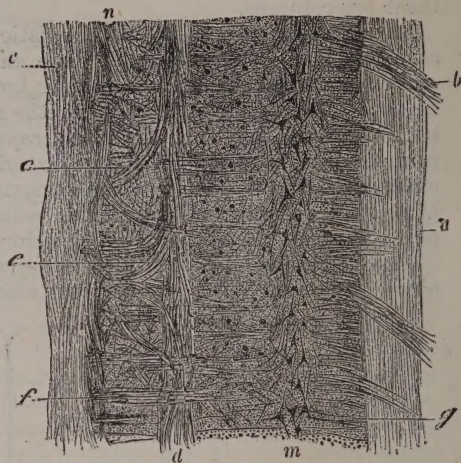


Fig. 811.—Sagittal section of spinal cord—*a*, anterior white column; *b*, anterior root; *c*, posterior root of nerve; *d*, lateral white column; *e*, oblique fibres of posterior root; *f*, pyramidal fibres passing to the anterior horn; *g*, pyramidal cells of anterior horn; *m*, column of cells.

vading the grey matter and giving rise to a network, the **reticular formation**. At the base of the posterior horn are large solitary cells whose axis-cylinder processes pass into the anterior nerve roots.

The proportion of grey and white matter varies at successive points of section, as shown in the accompanying diagram, the amount of grey matter (Gr)

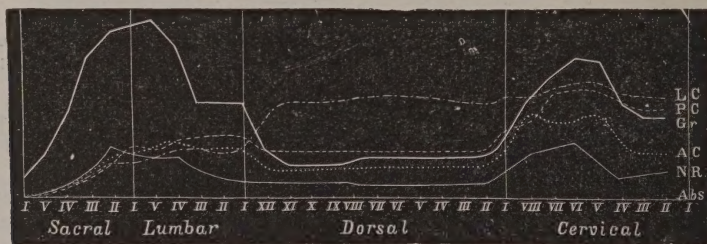


Fig. 812.—Diagram showing the relative amounts of grey and white matter in the spinal cord at different levels, as well as the sectional areas of the nerve-roots. Each mm. of ordinate represents a sq. cm. of sectional area—LC, lateral column; PC, posterior column; AC, anterior column; Gr, grey matter; NR, nerve roots. The subdivisions of the abscissæ represent the different levels.

varies with the sizes of the arising nerves, is absolutely and relatively largest in the lumbar region, and smallest in the lower dorsal. The relative sizes of the nerve roots (NR), anterior (AC), lateral (LC), and posterior columns (PC) is also shown and will be seen to fluctuate in the different regions, the lateral columns alone constantly increase from below upwards (fig. 812).

There is very little white matter in the conus terminalis, and scarcely any nerve matter exists in the filum terminale, a few rudimental medullated fibres are included in each side of this cord above, passing off as the occasionally present lowest coccygeal nerve, and all trace of nerve fibres vanishes below this point. These rudimental fibres present rudimentary nests of cells and represent the segmental nerves of the rudimental coccygeal somites, but they are inconstant, and variable even when present.

The white matter of the cord consists of certain columns or tracts of fibres, whose course can be determined by section, by degeneration in cases of lesion, or by experiment. The anterior column consists essentially of two vertical series of fibres, as shown in fig. 816—(a), an internal set, the uncrossed *direct*

pyramidal tract (column of Türek), which diminishes to the mid-dorsal region and there disappears. The fibres of this portion probably cross in the anterior white commissure of the cord to the opposite side, and end in the cells of the opposite anterior horn. This, however, has not been clearly traced.

(b.) The external series or anterior ground-bundle consists of fibres de-

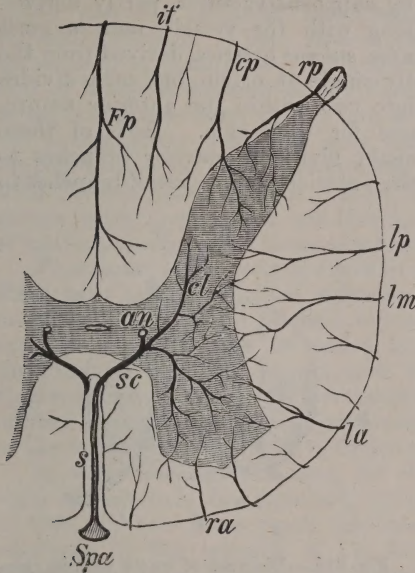


Fig. 813.—Arrangement of arteries in a transverse section of the spinal cord, $\times 8$ —*Spa*, anterior spinal; *Fp*, posterior fissure; *s*, anterior sulcine artery; *sc*, sulco-commissural artery; *an*, its ascending anastomotic branch; *Cl*, artery to Clarke's column; *ra*, anterior radicular artery; *la*, anterior lateral artery; *lm*, *lp*, middle and posterior lateral branches; *rp*, posterior radicular; *cp*, artery of posterior horn; *if*, interfunicular artery.

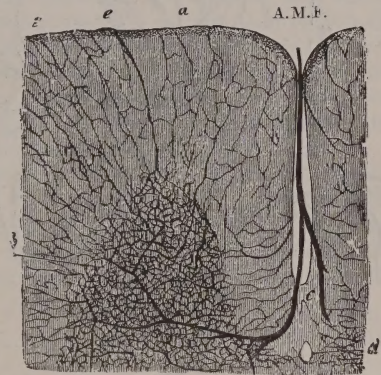


Fig. 814.—Injected vessels of anterior column, $\times 16$ —A.M.F., sulcine artery in anterior median fissure; *a*, anterior column; *e*, vaso-coronary branch; *b*, network in anterior horn; *d*, central canal.

scending from the medulla oblongata (p. 735), and passing to the anterior nerve roots.

The lateral column is the most complex and largest, and consists of **antero-lateral fibres** (*e*), which resemble those of the anterior ground-bundle, and consist of the same elements, together with some sensory fibres derived from the posterior roots. Internal to these, and closely resembling them, are the fibres of the **lateral limiting tract** (*f*), which pass through the formative reticularis. External to these are the fibres of the **crossed pyramidal tract** (*g*) which have been seen already above descending from the opercular lobe through the anterior two-thirds of the internal capsule, and through the middle part of the crura of the crus cerebri, from thence into the pyramid where they decussate, and from thence descend to the

anterior nerve roots. These are closely connected in their pyramidal part with the upper fibres of group (*a*), and they are traceable along the whole extent of the cord of which they form the surface in the lumbar and upper cervical areas. These probably convey voluntary impressions to the anterior roots.

A thin layer of white fibres overlies these in the uppermost cervical, lower cervical, and dorsal regions, the cerebellar tract (*h*), whose fibres are traceable upwards to the restiform body and cerebellum.

The two constituent parts of the posterior white column are the column of Goll (*c*), continuous upwards apparently from the posterior roots to the grey nuclei in the funiculus gracilis; and the column of Burdach (*d*), which passes upwards to the restiform body.

These white columns are permeated by support-structures, partly derived from the pia mater. This passes in along with the vessels, and is most abundant along the branches of the *anterior sulcine arteries*, derived from the anterior spinal. These arteries are usually single at origin, but each divides

into two within the anterior fissure, one for each side. Each of these again gives off *anterior branches* to the anterior horn, *internal branches* to

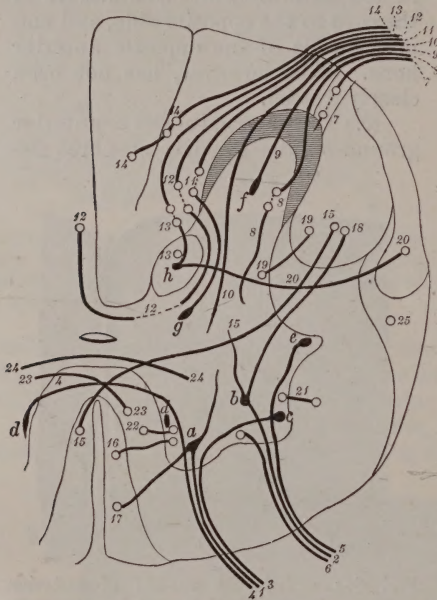


Fig. 815.—Scheme of fibres in spinal cord connected with the nerve roots. The vertical fibres represented by circles.

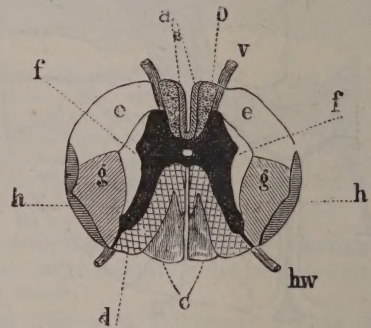


Fig. 816.—Diagram of tracts seen in cross section of the spinal cord, shown in transverse section—*a*, direct pyramidal tract; *b*, anterior column ground bundle; *c*, Goll's column; *d*, postero-external column; *e*, mixed lateral path; *f*, internal mixed lateral path; *g*, crossed pyramidal tract; *h*, direct cerebellar tract; *v*, anterior root; *hw*, posterior root. The grey matter is represented black.

Clarke's column, and anastomotic branches, which ascend to join the corresponding arteries above and below. Besides the posterior, septal, anterior, and posterior radicular arteries, already described, *anterior, median, and posterior lateral branches* from the lateral spinals enter the side of the column, and pass through the white fibres to the formatio reticularis and lateral horn.

Beside this purely connective tissue, sheathing the vessels and derived from the pia mater, there is a more abundant support-reticulum of neuroglia, derived from modified neural cells, with branches beset with neuro-keratin and small nucleated bodies, some of these cells are large, stellate in section (cells of Deiters), others are smaller. Much of the substantia gelatinosa consists of these cells, embedded in a dense network of the united protoplasm processes of the small nerve cells.

The fibres of each anterior nerve root consist:—

1. Of the axis-cylinder processes of the large cells of the anterior cornu on the same side (*a*, *b*, and *c*), (1, 2, and 5).
2. Of the axis-cylinder processes of cells of the opposite cornu crossing in the anterior commissure (4).
3. Of axis-cylinder processes from the large cells of the lateral horn in the regions where that exists.
4. Of fibres from the cells of Clarke's column.
5. Of axis-cylinder processes from the large cells at the base of the posterior horn.

The fibres of the posterior root which enters as a single bundle divide into—

1. An external radicular series which pass into the longitudinal fibres of Burdach's column. These, after a short course, become horizontal and enter the substantia gelatinosa. They are supposed to be the channels of the sensation of temperature, and of the cutaneous reflexes; (2) an internal radicular series, which also enter the column of Burdach, and pass at first longitudinally, but subsequently enter the grey matter of the posterior cornu. These are supposed to be the channels of tactile sensation. Some of these are connected with the small fusiform cells. Most of the fibres break up into the fine nerveplexus in the grey matter, and therein ascend. These are possibly the channels of tactile sensation, and those along which sensations of pain travel.

From some of the cells of Clarke's column in the lumbar portion of the cord, there pass processes which serve as shunts between the sensory and motor nerves of the anus and bladder, hence, in the cluster of cells in this region the anal and vesical centres are said to lie. The *nervi erigentes* are said to have their roots in Clarke's column, near the origin of the third sacral, the motor filaments travelling in the sympathetic rami communicantes from the lower lumbar nerves. The *nervi ejaculantes* in the male, and the *nervi parturientes* in the female, are said to have their centres probably a little higher.

It will thus be seen that, for the most part, the fibres of the anterior roots ascend into the pyramid, those of the posterior root in the column of Goll. When these reach the nucleus of the column they are displaced outwards by the opening of the fourth ventricle, but return again in the interolivary space wherein they decussate; most, if not all, ascending thence as the fillet.

NOTE TO p. 719.—The pituitary body or hypophysis is an oval mass, lying in the sella turcica, surrounded by cavernous venous tissue (p. 534), and consists of two closely united lobes. The anterior or stomodæal lobe is a brownish, crescentic mass of degenerate, epithelium-lined gland-tubules, united by connective tissue, with many vessels and lymph spaces, and is the fundus of the primitive mouth invagination (p. 15). The posterior or infundibular lobe is an oval mass of connective tissue, lying in the concavity of the fore-lobe, and is the thickened end of the infundibulum. It is probably the rudiment of an archaic sense-organ.

NOTE TO p. 684.—The facial nerve (p. 696) enters the internal auditory meatus in two bundles, the larger or *portio dura*, the smaller or *portio intermedia*, both lying above and indenting the auditory nerve, and then entering the aqueduct of Fallopius. In this canal it passes outwards between the cochlea and the vestibule to the inner wall of the tympanum, where it enlarges into the geniculate ganglion, in which its two parts unite, and turns backwards at right angles over the fenestra ovalis, then turning downwards to the stylomastoid foramen. It gives off (1) branches to the auditory nerve; (2) the great superficial petrosal which passes through the hiatus Fallopii (p. 664 and fig. 679, j); (3) a filament to join the lesser superficial petrosal (p. 605, and fig. 679, β); (4) the nerve to the stapedius (fig. 679, γ); (5) filament to join the external superficial petrosal branches of the sympathetic, which accompany the middle meningeal artery; (6) the chorda tympani which enters the tympanum by a hole between the pyramid and the edge of the membrana tympani, crosses

between the malleus and the long leg of the incus, and escapes through the canal of Huguier, where it is joined by a twig from the otic ganglion, and ends in the lingual nerve (p. 599); (7) a fine twig to the auricular branch of the vagus.—For the rest of its course see p. 576.

NOTE to p. 384.—The foetal testes lie in the abdomen, each being below and in front of the kidney and covered by a layer of peritoneum, the *mesorchium*. A faint ridge stretches from this upwards and downwards, the latter portion growing into a thick cord, while the former vanishes. This ridge, the *plica gubernatrix*, by the fifth month has become large, and consists, beneath the peritoneum, of a firm layer containing striped fibres continuous from the abdominal wall, and a central core of soft gelatinous connective tissue containing smooth muscle cells. The lower end of this cord at first rests on the deep abdominal ring, but by the end of the fifth month its extremity can be followed through the inguinal canal into the scrotum. The serous membrane enveloping the gubernacular cord is elongated downwards into a pouch which enters into the inguinal-canal-portion of the gubernacular cord, forming a gradually deepening pit, the *processus vaginalis*. As the foetal body grows this body does not commensurately extend, and in consequence the testis, to which its upper end is attached, is gradually drawn down until in the eighth month the length of the cord only equals that of the inguinal canal, and the testis is consequently drawn into the canal through the rings, its descent being facilitated by the pre-formation of the *processus vaginalis* (fig. 487, V.pc.). The neck of this sac (*ib.*, VI.) ultimately closes, and the *processus* becomes the *tunica vaginalis*.

By the end of the eighth month the testis has entered the scrotum, and by the end of the ninth the neck of the *processus vaginalis* has become obliterated. Failure in the obliteration allows of the formation of a congenital hernia into the *processus vaginalis*.

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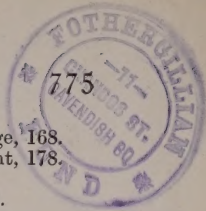
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